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ORIGINAL ARTICLES.

I.—On the Relations between the Genera *Syringolites*, Hinde, and *Roemeria*, Edwards and Haime, and on the Genus *Caliapora*, Schlüter.

By H. Alleyne Nicholson, M.D., D.Sc., F.G.S.,

Regius Professor of Natural History in the University of Aberdeen.

In a recent publication ("Anthozoen des rheinischen Mittel-devon," 1889) Professor Schlüter has put forward the conclusion that the genus *Syringolites*, Hinde, is identical with the much older genus *Roemeria*, Edwards & Haime, the former name thus becoming a mere synonym. From this conclusion I feel obliged to dissent, and I propose to show in the following brief communication that *Roemeria* and *Syringolites* are distinguished by important morphological characters, and that the latter is fully entitled to generic rank.

The genus *Syringolites* was founded by Dr. Hinde (Geol. Mag. Dec. II. Vol. VI. p. 244, 1879) for the reception of a beautiful and interesting coral from the Niagara Limestone of Canada, to which the name of *S. Huronensis* was given by its describer. The same species has subsequently been recognized as occurring in the Wenlock Limestone of Gotland. The corallum in *S. Huronensis* (Fig. 1) is composite and has the form of a flattened expansion, furnished with a basal epitheca, and closely similar in general aspect to specimens of the massive forms of *Favosites*, such as *F. Gothlandica*. The corallites resemble those of *Favosites* proper in being prismatic,

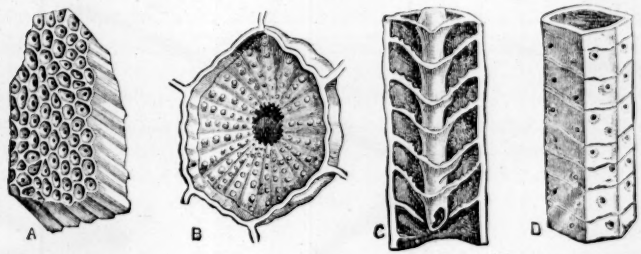


Fig. 1.—A, A fragment of a colony of *Syringolites Huronensis*, Hinde, of the natural size; B, A single calice of the same, enlarged eight times, showing the central tube, and radiating lines of septal tubercles; C, Part of a corallite of the same, split open, and enlarged six times, showing the composition of the central tube out of invaginated tabulæ; D, Part of a corallite of the same, viewed from the exterior and enlarged six times, showing the mural pores. Niagara Limestone, Manitoulin Island, Ontario.

thin-walled, closely contiguous, and furnished with one or more rows of small mural pores on each prismatic face. The corallites are intersected by numerous annular tabulæ, which are invaginated centrally so as to give rise to a median cylindrical tube, which occupies the centre of each visceral chamber, and is furnished with imperforate walls. The upper surfaces of the tabulæ show well-marked septal ridges (primarily twelve in number), which are covered with minute tubercles or spines, two to four rows of such tubercles apparently corresponding with a single septal fold. Increase of the corallum takes place by intercalicinal gemmation.

The essential characters of *Syringolites Huronensis*, as above briefly described, are that the prismatic corallites are *thin-walled*, and are furnished with numerous regularly-distributed mural pores, while the septal system is fairly represented by radiating tuberculated ridges, which are primarily twelve in number in each corallite.

The only corals which have been recognized as belonging to the genus *Roemeria*, E. & H., are the *R.* (*Calamopora*) *infundibulifera* of Goldfuss, and the *R. minor* of Schlüter, both of which occur in the Middle Devonian of Germany. I have had the opportunity of examining the original specimens of the former of these, which are preserved in the University Museum in Bonn; but, so far as I am aware, no complete microscopic examination of these has ever been carried out. There is, however, no doubt that *R. minor*, Schlüter, is congeneric with *R. infundibulifera*, Goldf., and through the kindness of Professor Schlüter, I have been enabled to make a thorough microscopic investigation of the former, which I shall therefore take as the type of the genus *Roemeria*.

The corallum in *Roemeria minor* forms small flattened expansions, composed of erect, polygonal, and contiguous corallites. Thin sections, both transverse and longitudinal (Figs. 2 and 3), show that the corallites are bounded by a thin and well-developed primordial wall, which is enormously thickened by a dense deposit of secondary sclerenchyma ("stereoplasma"), the visceral chamber being thus greatly constricted. The visceral chamber of the corallites, thus restricted, is traversed by a succession of infundibuliform tabulae, which are invaginated one into another, but can hardly be said to give rise to a definite median tube. The septa are practically undeveloped, though one may occasionally observe blunt vertical ridges, which are possibly of a septal nature. The mural pores are of very large size, and comparatively few in number, and are quite irregular in their distribution; while owing to the enormous thickening of the walls of the corallites, they present themselves as elongated canals joining the visceral chambers of contiguous tubes. Increase of the corallum takes place by means of intermural gemmation.

From the above short description of the structure of *Roemeria minor*, as illustrated by the accompanying figures of thin transverse and vertical sections, it will be obvious that *Syringolites*, Hinde, differs in characters of fundamental importance from *Roemeria*, E. & H. This will be sufficiently evident from the following summary:

(1) The corallites in *Roemeria* are enormously thickened by a secondary deposit of stereoplasma; whereas those of *Syringolites* are thin-walled, and resemble those of *Favosites* proper.

(2) The mural pores of *Roemeria* are of large size, are few in number, and are irregularly distributed; whereas those of *Syringolites* resemble the pores of *Favosites* proper in being of small size, numerous, and regularly distributed.

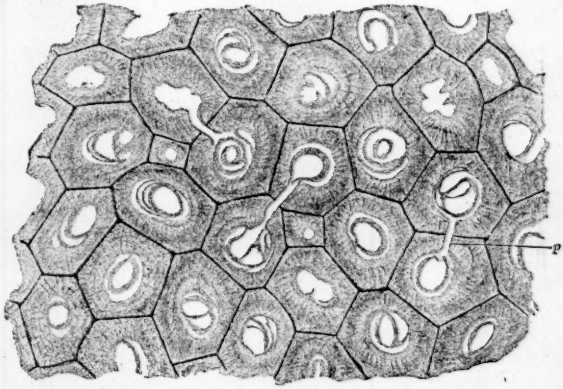


FIG. 2.—Transverse section of *Roemeria minor*, Schlüter, from the Middle Devonian rocks of Dahlem, in the Eifel, enlarged about six times. *p*. Mural pore.

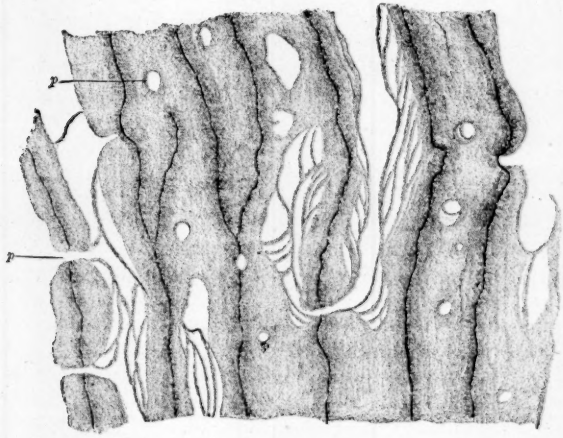


FIG. 3.—Vertical section of *Roemeria minor*, Schlüter, from the same locality, similarly enlarged. *pp*. Mural pores.

(3) The septal system in *Roemeria* is rudimentary or absent; whereas in *Syringolites* each corallite is provided with well developed septal ridges, the number of these structures in each tube appearing

to be primarily twelve, as is the case in *Heliolites*, *Halysites*, *Syringopora*, etc.

Upon the whole, therefore, it cannot be doubted that *Syringolites*, Hinde, is generically distinct from *Roemeria*, E. & H.; and it is not even clear that the two are very nearly related. If the septal system of *Roemeria* had been developed, the genus might be regarded as occupying to *Syringolites* a position analogous to that held by *Pachypora* with regard to *Favosites* proper; and, possibly, this view may be found ultimately to express the real relationships of the two. Both genera afford transitional links between the *Favositidæ* and the *Syringoporidæ*; but their precise relationships must in the meanwhile remain more or less a matter of conjecture.

Genus Caliapora, Schlüter.

The genus *Caliapora* has been proposed by Professor Schlüter for the reception of the well-known *Alveolites Battersbyi*, E. & H., from the Devonian rocks of Britain and Germany. I have long been of opinion that the peculiarities of *A. Battersbyi* are such that it is worthy of separation from *Alveolites* proper, as a distinct genus or

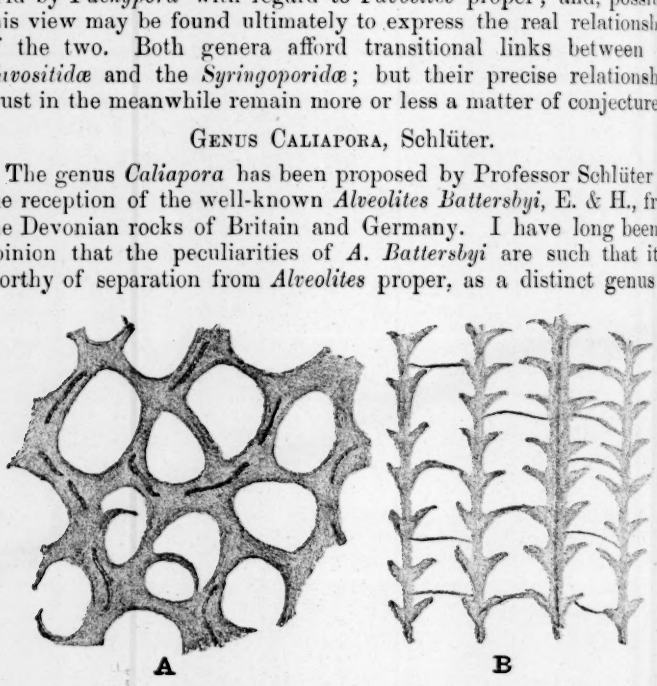


Fig. 4.—A. Tranverse section of *Caliapora Battersbyi*, E. & H., sp. enlarged seven times. B. Vertical section of the same. From the Middle Devonian of Dartington, South Devon.

subgenus; and I am therefore able to cordially concur in the course which Professor Schlüter has taken. At the same time I interpret the structure of *A. Battersbyi* in a somewhat different manner, and I consider that the familiar *Alveolites Labechei* of the Wenlock Limestone must find a place along with *A. Battersbyi*. I cannot, therefore, accept Professor Schlüter's definition of *Caliapora* as altogether sufficient; and I shall endeavour here to indicate what, in my opinion, are the essential characters of the genus.

In both *C. Battersbyi* and *C. Labechei* the corallum has all the general characters of that of *Alveolites* generally, and there is therefore no external feature which distinguishes the genus *Caliapora*. In *C. Battersbyi*, as pointed out by Schlüter, the corallites are subpolygonal and irregular in shape (Fig. 4); but this character is

not a vital one, since in *C. Labechei* the tubes have commonly the compressed form and alternating arrangement which is characteristic of the typical forms of *Alveolites*. Again, little importance can be attached to the mode of distribution of the mural pores, since in *C. Labechei* these structures seem to be confined to the short ends of the compressed corallites, whereas in *C. Battersbyi* they are asserted by Schlüter to occur indifferently on all the faces of the corallites. Of still less importance is the supposed absence of tabulæ, since this rests upon a misconception. Not only are tabulæ largely present in *C. Labechei*, but, in all the specimens of *C. Battersbyi* which I have examined, I have found these structures to be fairly well developed, though they are often comparatively few in number (Fig. 4, B). Some of the tabulæ of *C. Battersbyi* have the ordinary form of complete transverse plates; but this species is furnished in addition with numerous imperfect, cup-like tabulæ, which project but a short way into the visceral chamber of the corallites, and which have been compared by Professor Schlüter with swallows'-nests attached to the wall of a house. In *C. Labechei* all the tabulæ seem to be complete, and there are none of the peculiar incomplete or squamous tabulæ which occur in *C. Battersbyi*.

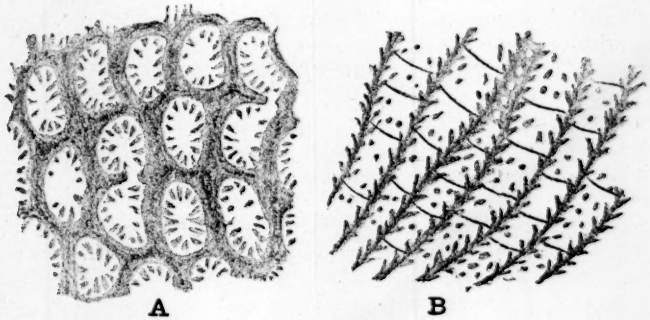


FIG. 5.—A. Transverse section of *Caliapora Labechei*, E. & H., sp. enlarged six times. B. Vertical section of the same, similarly enlarged. From the Wenlock Limestone of Much Wenlock.

The most characteristic feature of the genus *Caliapora*, as compared with *Alveolites*, is to be found in the fact that the corallites are provided with numerous strong ascending tooth-like processes, which must be regarded as of the nature of septa (Figs. 4 and 5). The existence of these strong tooth-like spines in *Caliapora Battersbyi* is recognized by Schlüter, but they are regarded as being due to the intersection of the cup-like squamous tabulæ above spoken of. In this view of their nature I am unable to agree, and I regard them as structures having an independent existence. This is clearly the case in *C. Labechei* (Fig. 5), where their septal nature is quite indisputable. If this view be correct, then the essential feature which distinguishes *Caliapora* from *Alveolites* is the possession by the former of strong tooth-like septal spines, which are developed in

a cycle within each corallite in *C. Labechei*, but are fewer in number in *C. Battersbyi*.

Finally, it may be pointed out that in typical examples of *C. Battersbyi* there appears to be the peculiar feature that the walls of certain of the corallites seem to be specially thickened, thus giving rise to strong vertical spines, which constitute a conspicuous feature in vertical sections. I have had no opportunity of observing the termination of these spine-like thickenings on the surface, and I am not clear as to their real nature.

II.—Prof. E. D. Cope, on the Proboscidea.

(PLATE XIII.)

THE following account of the Proboscidea, by Prof. E. D. Cope, appeared in a recent number of the "*American Naturalist*,"[1] and is so interesting, that we venture to give the more important part in full, and some few of the illustrations.—Edit. Geol. Mag.

"The Proboscidea are Ungulata, in which the second row of carpal bones has not moved inwards, so as to alternate with the first, and in which the second row of tarsal bones alternates with the first by the navicular extending over part of the proximal face of the cuboid. The teeth are modifications of the quadri-tubercular type, and canines are absent. To these general characters are added numerous subordinate peculiarities in the known genera and species, which make them among the most remarkable of living beings. These peculiarities are the result of a long period of development. It is one of the most curious facts of palæontology that the order does not make its appearance until the middle of the Miocene system, and the greater number of forms do not appear until the upper Miocene. That it existed earlier cannot be doubted, and that it originated from some Eocene Condylarthran is evident; but the intermediate forms are entirely lost to us as yet; and the phylogeny of the order is absolutely unknown. This is the more extraordinary, since the earliest known genus (*Dinotherium*) embraces only species of colossal size, and its immediate ancestors could not have been insignificant. We may regard *Phenacodus* as the first form we know of earlier than *Dinotherium*, but what a hiatus is expressed in this statement. It is to be anticipated that the gap will be filled by discoveries in Asia, or the Southern Hemisphere. South America may be probably excluded from this prospect, since the extensive researches made there by Burmeister, Ameghino, and Moreno, have not resulted in the discovery of any Proboscidea earlier than the Pliocene. Asiatic investigations have revealed nothing, as the proper formations have not been found, and the same is true of Africa. So we shall have to wait until the palæontology of the present home of the order is exposed to view, before we shall know of the steps which lead from *Phenacodus* to these mighty monarchs of the animal kingdom. The absence of primitive Proboscidea from North and South America and Europe, impels us to believe that the representatives of the order known to us from those regions are the descendants of immigrants from Asia and Africa.

[1] No. 268, April 1889, pp. 191–211, pl. ix.-xvi. and nine woodcuts.

But two families of Proboscidea are known. They are defined as follows :

Adult dentition embracing premolars and molars ; no superior incisors—*Dinotheriidæ*.

Adult dentition embracing one or two true molars only ; superior incisors—*Elephantidæ*.

The family of the *Dinotheriidæ* embraces one genus and four species, though a fifth species, *D. sindiense*, Lyd., from India, may belong, according to Lydekker, to another genus. The *Dinotherium indicum*, Falc., is known from a few teeth, which exceed in size those of the other species. The *D. giganteum*, Kaup, is found in several

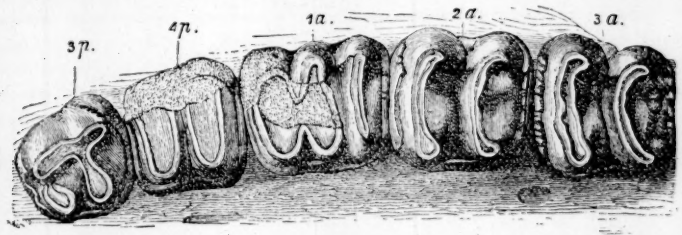


Fig. 1.—*Dinotherium giganteum*, Kaup, from the Middle Miocene of Samaran (Gers), France. (After Gaudry.) The left upper cheek-dentition ($\frac{1}{4}$ nat. size). *a* 1, 2, 3, true molars, *p*. 3, 4, premolars.

Miocene deposits of Europe. It was one of the largest of Mammalia, its femur exceeding in dimensions that of any other land mammal. The inferior incisors were robust, and cylindric in form. With the symphysis of the lower jaw they are decurved so as to form a most effective instrument for the tearing up of trees by the roots, or the pulling down of their branches. The temporal fossa is lateral, and the top of the head flat. The premaxillary region, though toothless, is prominent, and the nasal bones do not project. There is supposed to have been a short trunk. The skull measures three feet eight inches in length. Two smaller species are known, the *D. bavaricum*, from European, and *D. pentapotamiæ*, from Indian, Miocene beds.

In *Dinotherium* all the molars and premolars have two transverse crests, excepting the first (posterior) premolar, and its deciduous predecessor, which have three cross-crests.

The genera of the *Elephantidæ* are the following :

I. Inferior incisors and premolars present. Superior incisors with enamel band—*Tetrabelodon*, Cope.

II. Premolars, but normally no inferior incisors ; intermediate molars isomerous ; superior incisors with enamel-band – *Dibelodon*, Cope.
Intermediate molars isomerous ; superior incisors without enamel band—*Mastodon*, Cuv.
Intermediate molars heteromerous ; superior incisors without enamel band—*Emmenodon*, Cope.[1]

III. No premolars, nor inferior incisors.
Intermediate molars heteromerous. Superior incisors without enamel band—*Elephas*, Linn.

[1] Gen. nov. type, *Elephas Cliftii*, Falc. & Cautl. (*Mastodon elephantoides*, Clift).

The characters assigned to the above genera are sufficient to separate them, but they have not come into general use for two reasons. One is the difficulty of verifying some of them, especially the presence of premolars, owing to the difficulty of obtaining specimens of young individuals. The other is the indisposition of naturalists to abandon the system of Falconer. As is well known, this able palæontologist distinguished the genera by the number and depth of the transverse crests of the molar teeth, and the extent to which their interspaces are filled with cementum. This arrangement is insufficient, since it neglects the equally important characters above mentioned; and as observed by Lydekker[1] it fails to furnish clear definitions. He remarks, under the head of the genus *Elephas*:—"There is no character by which the present genus can be distinguished from *Mastodon*; and the division can be therefore only regarded as a matter of convenience." The characters presented in the above table are on the other hand very distinctive, and can be applied in all cases where we have the necessary information. This has not yet been obtained as regards all the species, and I have placed some of them in their respective genera provisionally. Such species are marked with an *i*, when the condition of the incisors is unknown and with a *p*, when the same is true of the premolars. The species of the family described thus far are as follows:[2]—

Mastodon	(*Tetrabelodon*)	*brevidens*,[3] Cope, sp. nov. N. America, *i.p.*
,,	,,	*turicensis*, Schinz. Europe.
,,	,,	*angustidens*, Cuv. Europe.
,,	,,	,, *palæindicus*, Lyd. India.
,,	,,	,, *proævus*, Cope, N. America.
,,	,,	*productus*, Cope. N. America, ? Mexico.
,,	,,	*euhypodon*, Cope. N. America, *p.*
,,	,,	*pandionis*, Falc. Cautl. India.
,,	,,	*pentelici*, Gaudry.[4] Europe, *p.*
,,	,,	*campester*, Cope. N. America, *p.*
,,	,,	*longirostris*, Kaup. Europe.
,,	,,	? *serridens*, Cope. Texas, ? Mexico, ? Florida,[5] *i.p.*
,,	(*Dibelodon*)	*shepardi*, Leidy. California, Mexico, *p.*
,,	,,	*cordillerarum*,[6] Desm. S. America.
,,	,,	*tropicus*, Cope. S. America and Mexico, *p.*
,,	,,	*humboldtii*, Cuv. S. America.
	Mastodon	*americanus*, Cuv.[7] N. America.
	,,	*borsoni*, Hays. Europe, *p.*
	,,	*falconeri*, Lydd. India, *p.*
	,,	*mirificus*, Leidy. N. America, *i.p.*
	,,	*sivalensis*,[8] Cautley. India, *p.*

[1] Catalogue of Fossil Mammalia in the Brit. Mus., pt. iv. p. 72.

[2] In compiling this list I have been greatly aided by the Memoirs of Lydekker in the "Palæontologia Indica" and the Catalogue of the British Museum.

[3] *M. proævus*, Cope, 1884, not 1873.

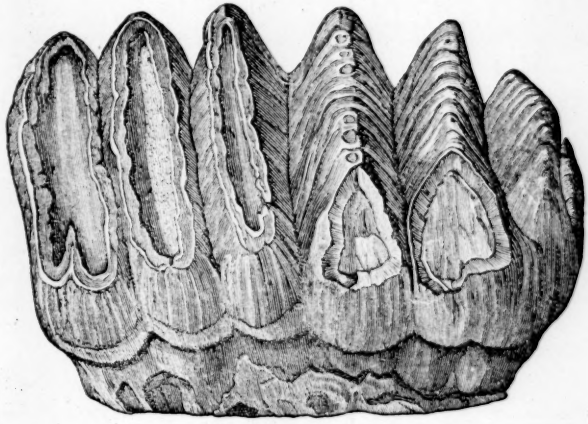
[4] According to Lydekker no premolars have been seen in this species.

[5] *M.? floridanus*, Leidy.

[6] *M. andium*, Cuv. According to the recent researches of Burmeister, this species does not possess mandibular tusks (Sitzungsb. Kön. Preuss. Akad. Wiss., Berlin, 1888, p. 717). Hence the specimen from Mexico with such tusks, reported by Falconer, must be assigned elsewhere.

[7] This species is said by Lydekker not to possess premolars. Leidy, Report U.S. Geol. Surv. Terrs. Pl., figures a tooth as a premolar, and similar specimens are not uncommon.

[8] According to Lydekker, premolars have not been observed.



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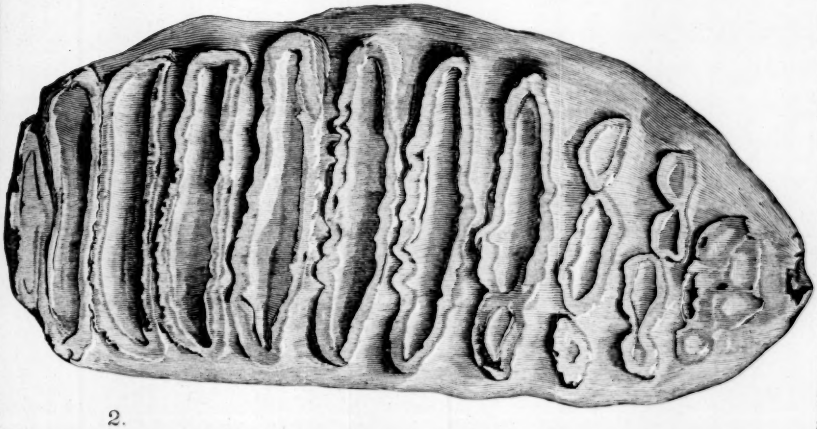

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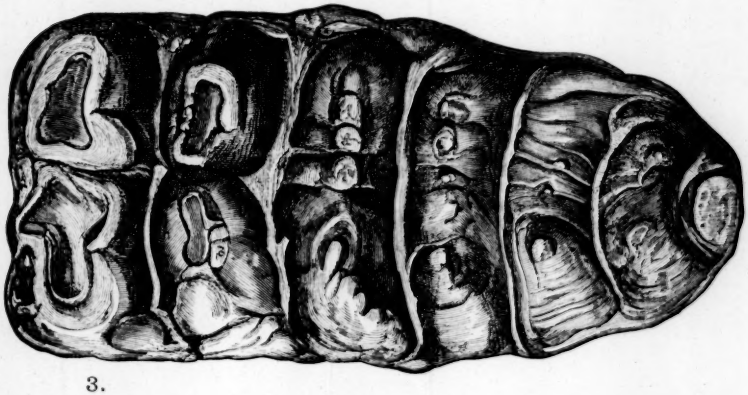


3.

FORMS OF PROBOSCIDEAN MOLARS.

To illustrate Professor E. D. Cope's paper on the Proboscidea.

	Mastodon	*arvernensis*, C. & J. Europe.
	,,	? *punjabiensis*, Lyd. India, *p.*
	,,	*latidens*, Clift. India.
	Emmenodon	*elephantoides*,[1] Clift = *Elephas*, *Cliftii*. India to Japan.
(*El.*)	,,	*planifrons*, Falc. & Cautl. India.
	Elephas	*bombifrons*, Falc. & Cautl. India, ? China.
	,,	*ganesa*, Falc. & Cautl. India.
	,,	*insignis*, Falc. & Cautl. India to Japan. [N. Africa.
	,,	*meridionalis*, Nesti. Middle and South Europe, and
	,,	*hysudricus*, Falc. & Cautl. India.
	,,	*antiquus*, Falc. Europe. ? W. Africa.
	,,	*mnaidriensis*, Leith-Adams. Malta.
	,,	*melitensis*, Falc. Malta.
	,,	*namadicus*, Falc. & Cautl. India to Japan.
	,,	*primigenius columbi*, Falc. N.W. America and Mexico.
	,,	,, *primigenius*, Blum. Northern Hemisphere.
	,,	,, *americanus*, De Kay. N.E. America.

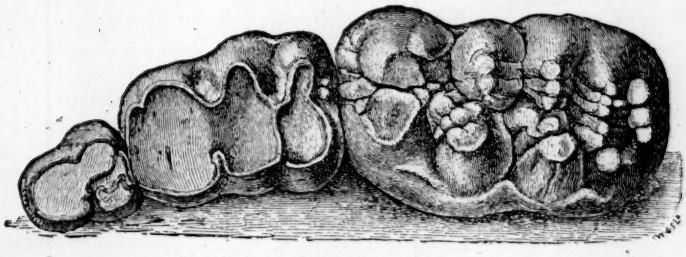


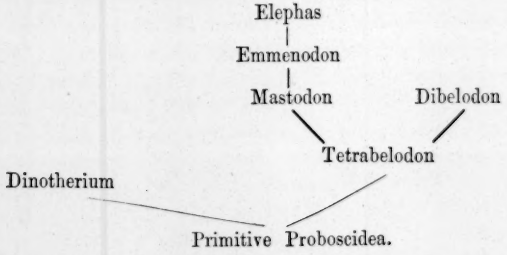
Fig. 2.—*Mastodon longirostris*, Kaup, Upper Miocene, Eppelsheim, Hessen-Darmstadt. (After Gaudry) the left milk-molars (nat. size).

To these we must add the two existing species *Elephas africanus* and *E. indicus*. Several species are not sufficiently known for reference to their proper genus. Such are *Mastodon perimensis*, Falc., Cautl., India; *M. atticus*, Wagn., S. Europe; *M. serridens*, Cope, Texas; *M. cautleyi*, Lyd., India; and *M. obscurus*, Leidy, N. America. In these the characters of both the incisor and the premolar teeth are unknown. In some of the species referred above to Mastodon, mandibular tusks are present in the young, and occasionally one is retained to maturity, as sometimes seen in *M. Americanus*. But such individuals are exceptional among their species. In some other species, while the males possess them, they are wanting in the females. The specific character is in this case derived from the male.

The molar dentition in this family possesses a number of peculiarities which have been worked out mainly by Falconer, Owen, and Lydekker. There are probably deciduous molars in all the species, and they are generally three in number; the posterior of these has the same number of cross-crests as the posterior premolar, which immediately succeeds it. The number of crests diminishes to the first of the series. There are two or three premolars in most

[1] *Mastodon*, Clift.; *Stegodon*, Falc.; *Elephas*, Lyd.

forms of the family, but in the genus *Elephas* they have disappeared. In all the species they are shed early in life in order to make way for the true molars. As the latter teeth are very large, and the fore and aft extent of the jaw is small, there is only space for one or two of them at a time. In most of the species the last molar so much exceeds the others in size, that it occupies the entire jaw, and the other molars are shed in order to accommodate it. In the genera *Tetrabelodon*, *Dibelodon* and *Mastodon*, the last premolar, and the first and second true molars are isomerous, *i.e.* have the same number of cross-crests. In *Emmenodon* and *Elephas* they are heteromerous; that is, the number of cross-crests successively increases from front to rear. Thus in the three genera named the ridge formula is: P.M. 2–2–3; M, 3–3–4 and P.M. ?–?—4; M. 4–4–5 or 4–5–6. In *Emmenodon* the ridge formula is P.M. ?–?–?–5; M. 6–7—6—7–8; and P.M. ?—6–7; M. 7—8–9—10–12. In *Elephas* the formula extends from M. 6—6–7—8–9, to M. 9–15—14–16—18–27. Each genus then has a certain range of variation in the number of molar crests, extending from a smaller to a larger number. This successive increase in complexity has been regarded by Falconer as the index to the successive evolution of the species, and rightly so. As already remarked, however, other measures of the same succession cannot be overlooked, especially as the ridge formula changes in so gradual a manner as to render it unavailable as a basis of exact divisions, as has been remarked already by Lydekker. It is evident that the primitive Proboscidea had incisor teeth in both jaws, and that these had more or less of the usual enamel investment. The gradual modifications of these features is therefore another indication of the line of descent of these animals. The primitive Proboscidea had likewise four premolars, as is now seen in *Dinotherium*. The successive loss of these teeth is no less an index of the evolution of the modern types of the order, than the other modifications referred to. In general, then, the phylogeny of the order may be represented thus:



Within each genus certain parallel modifications of the composition of the crowns of the molar teeth may be observed. The cross-crests may be single, or they may be divided up into tubercles. The valleys between them may be open, (1) or they may be blocked by (2) a system of single intermediate tubercles; (3) by numerous intermediate tubercles; or (4) by the thickening of the primary tubercles. I arrange the species according to these characters.

	Tetrabelodon.	Dibelodon.	Mastodon.
1.	*T. ? brevidens.*		*M. americanus.*
	T. turicensis.		*M. borsoni.*
			M. latidens.
2.	*T. angustidens.*	*D. shepardi.*	*M. ? cautleyi.*
	T. productus.	*D. cordillerarum.*	*M. falconeri.*
	T. serridens.	*D. tropicus.*	
	T. euhypodon.		*M. arvernensis.*
	T. longirostris.		
3.	*T. campester.*	*D. humboldtii.*	*M. sivalensis.*
	T. pandionis.		*M. punjabiensis.*
4.			*M. mirificus.*
			? M. atticus.

Parallels between the species of *Emmenodon* and *Elephas* also exist. As but two species of the former genus are known, we must look for future discoveries to increase the number of correspondences. The species of both genera which approach nearest to *Mastodon* have a smaller number of cross-crests, which are of lesser elevation,

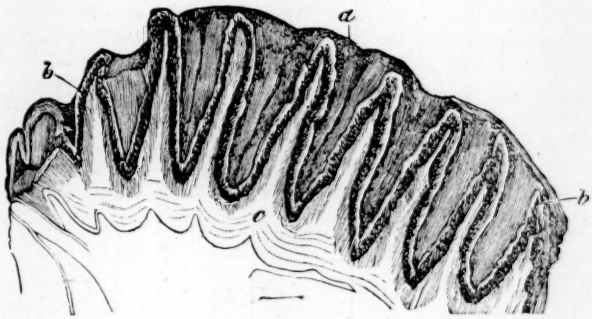


Fig. 3.—*Elephas planifrons*, Falc. & Cautl. Pliocene, Siwalik Hills, India. Vertical longitudinal section of 2nd upper true molar (⅓ natural size). *a*, cement; *b*, enamel; *c*, dentine.

and whose intervening valleys are occupied by but a shallow deposit of cementum. These are the *Stegodons* of Falconer; (1). In the other group (2) the crests are numerous and elevated, and their interspaces are filled with cementum.

	Emmenodon.	Elephas.
1.	*E. elephantoides.*	*E. bombifrons.*
		E. ganesa.
		E. insignis.
2.	*E. planifrons* (see Fig. 3).	*E. meridionalis.*
		E. hysudricus.
		E. antiquus, etc.

It is observable that each type of molar teeth of the three genera first compared has representatives in the regions where their species occur: North America, Europe, and India.

The North American species of this family are distinguished by the following characters of the molar teeth[1]."

[1] From the American Naturalist, 1884, p. 524.

I. Intermediate molars with not more than three crests (trilophodont).
α. Crests acute, transverse.
β. Valleys uninterrupted.
Last superior molar with three crests and a heel; crests low, not serrated.—*T. brevidens.*

Last superior molar with four crests and a heel; crests elevated, not serrated.—*M. Americanus.*
ββ. Valleys interrupted.
Edge of crest tuberculate.—*T. serridens.*
αα. Crests transverse, composed of conic lobes.
β. Valleys little interrupted.
Last inferior molar narrow, with four crests; an accessory tubercle in each valley. *D. shepardi.*
β. Valleys interrupted.
Last inferior molar with four crests and a heel; symphysis short, M. 150; smaller size.—*T. euhypodon.*
Last inferior molar with four crests and a cingulum, symphysis longer, M. 280. Size medium.—*T. productus.*
Last inferior molar with five crests and a heel, symphysis very long, M. 450. Size largest.—*T. angustidens.*
'α α α. Crests broken into conic lobes; those of opposite sides alternating.
Last inferior molar narrow, supporting four crests and a heel.—*T. obscurus.*'
II. Intermediate molars with four transverse crests (tetralophodont).
A long symphysis; crests well separated, tubercular, with accessory lobes interrupting valleys.—*T. campester.*
Symphysis very short; crests thick, closing valleys by contact; no accessory cusps (Leidy).—*M. mirificus.*
III. Intermediate molars with 9–16 crests.
β. Valleys filled with cementum.
Last molar with 18–27 cross-crests.—*Elephas primigenius.*

The stratigraphical position of these species is as follows:—

Pleistocene.
Mastodon americanus.
Elephas primigenius (less abundant).
Pliocene.
Elephas primigenius (more abundant.)
Tetrabelodon serridens (horizon probable).
Dibelodon shepardi
Upper Miocene (Loup Fork).
Tetrabelodon euhypodon.
,, *productus.*
,, *angustidens.*
,, *campester.*
Mastodon mirificus.
Ticholeptus bed.
Tetrabelodon brevidens."

Prof. Cope then proceeds to give an account of the American species, *M.* (*Tetrabelodon*) *obscurus*, Leidy, *M.* (*Dibelodon*) *Shepardi*, Leidy; the latter of which is from the Pliocene of the valley of Mexico. *M.* (*Tetrabelodon*) *brevidens*, Cope, is the oldest North American species, and presents a very simple type of molar: it is from the *Ticholeptus* bed of Montana. *M. Tetrabelodon angustidens*, Cuv., occurs in the Loup Fork beds of Kansas, Nebraska, and Dakota. The molar teeth exceed in size those of the typical European form. "It may become necessary," says Prof. Cope, "to distinguish this form as a species under the name of *Tetrabelodon proavus.*" The author adds that, "Probably this species has been

recorded by Whitfield from the Phosphate beds of South Carolina, and compared with *M. obscurus*." A figure of the European form is given on p. 447, Fig. 6. *M.* (*Tetrabelodon*) *euhypodon*, Cope, is also from the Loup Fork beds of Kansas, and is known by a nearly perfect left mandibular ramus, with last molar tooth and tusk, and an entire palate with both last molar teeth and tusks. "The superior tusks," says Cope, "are compressed distally, and the inferior tusks are large and have an enamel band; they are cylindric." *M.* (*Tetrabelodon*) *productus*, Cope, is abundant in the Loup Fork beds of New Mexico; it is the only species in which three upper premolars have been demonstrated; other species having generally two. *M. Tetrabelodon campester*, Cope, is a rather large species, with a very long symphysis of the lower jaw and a low ramus. It is in some measure allied to *M.* (*T.*) *longirostris* of Europe, but the symphysis is longer and the teeth more complex. This species is also from the Loup Fork beds of Kansas and Nebraska. *M.* (*Dibelodon*) *Shepardi*, Leidy, was founded on an inferior sixth molar from California. Cope subsequently described other specimens from the Pliocene of Mexico, where it is abundant. *M.* (*Tetrabelodon*) *serridens*, Cope, was founded on a first or second true molar from Texas. It is peculiar among American species in its acute, elevated, entire crests with tuberculo-serrate edges.

Mastodon mirificus, Leidy, is known from a left ramus of a lower jaw which supports the last molar. Its symphysis is short and acute.

"*Mastodon Americanus*, Cuv., is the best known and latest in time of the American elephants. It is one of the largest species, and, after *T. brevidens*, possesses the simplest molar dentition. The symphysis of the lower jaw is short and decurved. The skull is wider and less elevated than that of the Mammoth, and the tusks are shorter and less recurved. It was very abundant during the Pleistocene age throughout North America, from ocean to ocean, and as far south as Mexico; but it has not been found in the latter country. Its remains are usually found in swamps, in company with recent species of Mammalia, and with *Equus fraternus* and *Bos latifrons*. The carbonaceous remains of its vegetable food have been found between its ribs, showing that, like the Mammoth, it lived on the twigs and leaves of trees.

It is at first sight curious that this, the simplest of the family of Elephants in the characters of its molar teeth, appears latest in time on this continent. But it must be regarded as an immigrant from the Old World, where an appropriate genealogy may be traced. Its nearest ally, *Mastodon borsonii*, existed just anterior to it, during the Middle and Upper Pliocene, and this species was preceded in turn in the Middle and Upper Miocene by the *T. turicensis*, which possesses the same simplicity of the molar teeth. In its mandibular tusks the latter possesses another primitive character which was nearly lost by its North American descendant."

"*Elephas primigenius*, Blumenbach, 'the Mammoth,' was at one time distributed throughout North America, as far south as the valley of Mexico inclusive. Its remains are found in the Upper

Pliocene of Oregon, and in the Pliocene of Mexico, unaccompanied by the *Mastodon americanus*, which had not appeared by that time. In the Eastern States its remains occur with those of the *Mastodon*

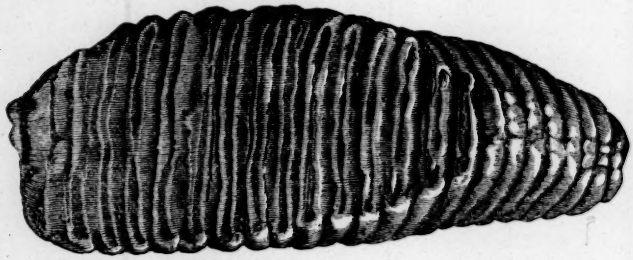


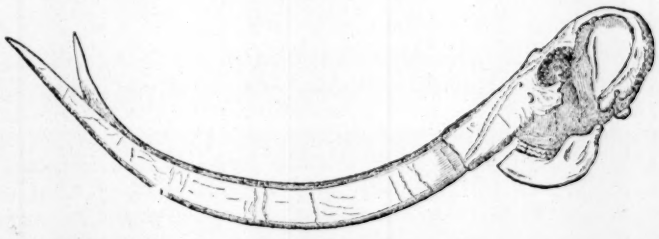
Fig. 4 —*Elephas primigenius*, Blum., the third left upper true molar; dredged off the Dogger Bank, North Sea (one-third nat. size). The lower border of the figure is the inner border of the specimen. Original in British Museum (Nat. Hist.).

americanus at the Big Bone Lick, in Kentucky. It was not found in the Port Kennedy, Pennsylvania, Bone-fissure, although the *Mastodon* was there. This absence may be accidental. Leidy says,[1] The animal (*Elephas primigenius americanus*) was probably of earlier origin, and became earlier extinct than the *Mastodon*, an opinion which my own observations confirm. Since no earlier species of Elephant proper is known from North or South America, we must regard this one as an immigrant from Asia, where, indeed, its remains abound. It remained longer in Siberia than in North America, since whole carcasses have been discovered imprisoned in the ice, near the mouth of the river Lena. These specimens had a covering of long hair, with an under layer of close wool.

Leidy and Falconer have observed that the teeth of the Elephants from eastern North America can be easily distinguished from those of the Mammoth by the greater alternation of the enamel plates. Leidy also observes that the lower jaw is more acuminate in the former. He proposed, therefore, to distinguish it as a species, using Dekay's name *E. americanus*. Teeth from Escholtz Bay, Alaska, he regards as belonging to the true *E. primigenius*.

Falconer regarded the true Elephant of Texas as a distinct species, which he named *E. columbi*. He distinguished it by the coarse plates of the enamel, and by the wide lower jaw, with curved rami, and short symphysis. So far as the dentition goes, I have specimens of this type from Colorado and from Oregon. The Oregon specimen presents the same type of lower jaw as does one from Texas, in my possession. Specimens from the valley of Mexico are abundant in the museums of the city of Mexico, and their characters do not differ from those from Texas. I have in my museum an entire skull, lacking the lower jaw, from the 'orange sand' of the city of Dallas, in north-eastern Texas, which only differs in form from that of the *E. primigenius*, as figured by Blumenbach and Cuvier, in the shorter and wider premaxillary region. This is one-half wider than long (from the molar alveolus), while in the Ilford Mammoth in the

[1] Extinct Mammalia of Dakota and Nebraska, p. 398.



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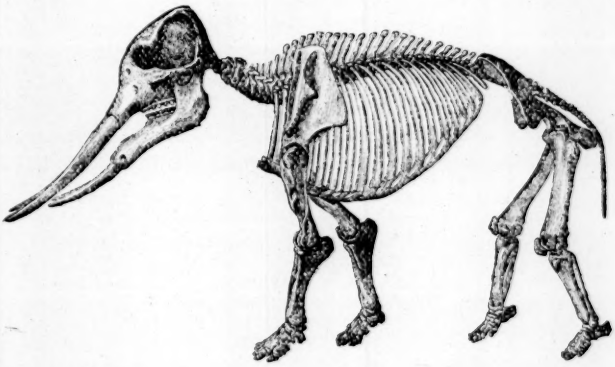

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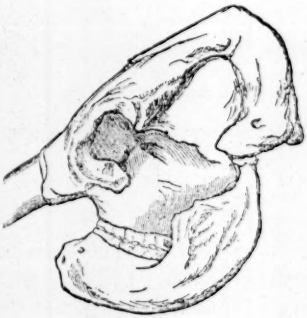

7.

8.

FORMS OF SKULLS AND SKELETON OF PROBOSCIDEA.

British Museum, figured by Leith Adams,[1] the length of this region equals the width. The skull agrees with those of *E. primigenius*, and differs from those of *E. indicus* in the narrow proportions of the posterior part of the cranium. The teeth are of the coarse-plated *E. columbi* type. The individual is not very large, though old. The diameter of the tusks at the alveolus is 110 mm. In a fragment of a huge specimen from south-western Texas, the diameter of the tusk at the base is 210 mm.

As a result it is not clear that the two American forms can be distinguished as yet from the *Elephas primigenius*, or from each other, except as probable sub-species, *E. p. columbi*, and *E. p. americanus*. But more perfect material than we now possess may yet enable us to distinguish one or both of these more satisfactorily. No American species of the family exceeded this one in general dimensions, especially the form *E. p. columbi*."

EXPLANATION OF PLATE XIII. FORMS OF PROBOSCIDEAN MOLARS.

FIG. 1.—*Elephas* (*Emmenodon*) *Cliftii*, Falconer & Cautley. The first (?) left upper true molar in an early stage of wear; from the Siwaliks of Burma ($\frac{1}{2}$ nat. size). The lower border of the figure is the inner border of the specimen. (The original preserved in the Museum of the Geological Society of London.)

FIG. 2.—*Elephas antiquus*, Falconer. The first left upper true molar in a half worn condition; from the Pleistocene of Grays, Essex ($\frac{3}{4}$ nat. size). The lower border of the figure is the inner border of the specimen. (Original preserved in the British Museum, Natural History.)

FIG. 3.—*Mastodon latidens*, Clift. The third left upper true molar of a small individual in a partially-worn condition; from the Pliocene of Borneo ($\frac{3}{5}$ nat. size). The lower border of the figure is the inner border of the specimen.

EXPLANATION OF FIGURES UPON PAGE 447.

Forms of Skulls and Skeleton of Proboscidea.

FIG. 5.—*Elephas ganesa*, Falconer & Cautley. Profile of the skull; from the Siwalik Hills ($\frac{1}{32}$ nat. size). [After Gaudry.] The original preserved in the British Museum (Natural History).

FIG. 6.—*Mastodon* (*Tetrabelodon*) *angustidens*, Cuvier. [After Gaudry.] Middle Miocene, Sansan (Gers), France. The entire skeleton restored and greatly reduced.

FIG. 7.—*Elephas planifrons*, Falc. & Cautl. Profile of skull restored; from the Pliocene of the Siwalik Hills ($\frac{1}{16}$ nat. size). [After Gaudry.]

FIG. 8.—*Mastodon sivalensis*, Cautley. Profile of skull restored; from the Pliocene of the Siwalik Hills ($\frac{1}{16}$ nat. size). [After Gaudry.]

III.—PRELIMINARY NOTES ON SOME NEW AND LITTLE-KNOWN BRITISH JURASSIC FISHES.[2]

By A. SMITH WOODWARD, F.G.S., F.Z.S.,
Of the British Museum (Natural History).

SINCE the works of Agassiz and Egerton, few contributions have been made to the knowledge of British Jurassic "Ganoid" and "Teleostean" Fishes, and a considerable amount of undescribed material has thus accumulated in various collections. Much more progress has been made upon the Continent, where the Lithographic

[1] Mon. Pal. Soc. 1879, Brit. Foss. Elephants, p. 69, pl. vi. and vii.

[2] Read before Section C (Geology), British Association, Newcastle, Sept. 1889.

Stones of Bavaria, Würtemberg, and Ain, especially, yield a rich assemblage of forms in a remarkable state of preservation; and it is now an interesting study to compare the British Jurassic fossils with their well-known continental allies. Such an undertaking is facilitated by the recent appearance of Prof. Dr. K. A. von Zittel's admirable critical summary of the extinct Mesozoic fishes;[1] and it is the object of the present notice to offer some preliminary remarks upon a few of the more prominent types observed by the author in English collections.

1. *Eurycormus grandis*, sp. nov.

In 1863, A. Wagner[2] described a genus of fishes from the Lithographic Stone of Eichstädt, Bavaria, under the name of *Eurycormus*, making known a single species, *E. speciosus*; and in 1887, Prof. v. Zittel added some supplementary information to the original diagnosis, while publishing detailed figures of the vertebræ. No precise particulars, however, concerning the cranial osteology and dentition have hitherto been forthcoming; and the recent discovery by Mr. Henry Keeping, in the Kimmeridge Clay of Ely, of a fine head of *Eurycormus*, not only makes known the occurrence of a new species of the genus in England, but reveals structural features of considerable taxonomic significance. The specimen is preserved in the Woodwardian Museum, Cambridge, and the author is indebted to the kindness of Prof. McKenny Hughes, F.R.S., for the opportunity of undertaking a detailed study of its characters. The skull, jaws, and opercular apparatus agree precisely in general form and proportions with the corresponding parts figured in Wagner's typical species, while two anterior vertebræ exhibit the characters assigned to them by v. Zittel. The Ely species, however, is nearly three times as large as the Bavarian form, and differs (according to Wagner's description) in the superficial tuberculation of several of the head-bones; it may therefore receive the distinct specific name of *Eurycormus grandis*. The maxilla is narrow, and its arched margin is provided with a single close series of small slender teeth; the vomerine or palatine bones (or both) bear a cluster of similar teeth of larger size; and the inner side of the mandible seems to be constituted by the splenial element, provided with at least one series of small teeth, while for a short space near the anterior end of each dentary are observed the sockets of about nine large teeth. Each dentary bone is deep and plate-like, and, though much crushed, doubtless inclined inwards in its inferior half; and a very large elongated azygous jugular plate extends between the rami as far back as the suture between the dentary and angular elements. The hyomandibular bone is more lamelliform than in *Pachycormus*, etc., thus more nearly resembling the same bone in *Caturus*, the Leptolepidæ, and modern Teleosteans.

[1] "Handbuch der Palæontologie," vol. iii., pts. i. ii. (1887–88).

[2] A. Wagner, "Monographie der fossilen Fische aus den lithographischen Schiefern Bayerns," Abh. k. bay. Akad. Wiss., cl. ii. vol. ix. (1863), p. 707, pl. iv.

2. *Strobilodus suchoides*, Owen, sp.

An examination of the type-specimen of *Strobilodus giganteus*, Wagner,[1] in the Munich Museum, has convinced the present writer of its generic identity with the so-called *Thlattodus suchoides*, Owen,[2] as already suggested with hesitation by v. Zittel (*loc. cit.* p. 229). One more Bavarian type is thus added to the fish-fauna of the English Kimmeridge Clay; and, as will shortly be pointed out elsewhere, there is evidence of still another British species of the same genus ranging as far upwards as the Purbeck Beds (Brit. Mus. 46,911).

3. *Hypsocormus Leedsi*, sp. nov.

The genus *Hypsocormus* was founded by Wagner in 1863,[3] and, as remarked by v. Zittel, only two species are yet recognized, these being apparently confined to the Bavarian Lithographic Stone. Characteristic portions of the jaws of two other species, however, have been discovered in the Oxford Clay of Peterborough, by Mr. Alfred N. Leeds, of Eyebury, who has kindly entrusted them to the present writer for elucidation; and although the dentition of the genus has not hitherto been described in detail, the recent acquisition by the British Museum of a fine example of *Hypsocormus macrodon* from Solenhofen, renders a direct comparison of actual specimens possible.

The larger species from Peterborough, which may be appropriately named *H. Leedsi*, is represented by the anterior extremity of the snout associated with two fragments of the skull (No. 39, Leeds Coll.), indicating as large a fish as *H. macrodon*. The snout is obviously a compound bone, but the discussion of the homologies of its parts may be deferred. As in the Solenhofen species just mentioned, it is obtusely pointed, the two sides meeting approximately in a right angle at its anterior termination; and the external surface is finely granulated. As in *H. macrodon*, also, there is a pair of large tusk-like teeth, rounded in section, arising from sockets in the middle of the bone; but, whereas in the species just referred to, these "tusks" are directed vertically downwards, in *H. Leedsi* they are much inclined forwards, and, if perfect, would doubtless project beyond the front of the supporting bone. An irregular cluster of small, stout, conical teeth occurs on each side of the central pair, and two of these outer teeth, larger than the others, are placed directly in front.

The abraded anterior extremity of a large right mandibular ramus of *Hypsocormus* in Mr. Leeds' collection (No. 38) also probably pertains to *H. Leedsi*, corresponding to the above-described snout in size; and this fossil is interesting as exhibiting the form and proportions of the splenial element. The dentary constitutes the outer

[1] A. Wagner, "Beitr. Kennt. lith. Schief. Fische," Abh. k. bay. Akad. Wiss., cl. ii. vol. vi. (1851), p. 75, pl. ii.

[2] R. Owen, "On a Genus and Species of Sauroid Fish (*Thlattodus suchoides*, Ow.) from the Kimmeridge Clay of Norfolk," Geol. Mag. Vol. III. (1866), pp. 55-57, Pl. III.

[3] A. Wagner, *loc. cit.* (1863), p. 677.

side of the jaw and exhibits the abraded remains of a series of teeth, of moderate size, firmly implanted in sockets; while the splenial is a short, stout, lenticular bone, perhaps entering somewhat into the symphysis, but having its thickest portion immediately behind, supporting two great rounded tusks, in sockets, accompanied in front and behind by an irregular cluster of relatively minute stout conical teeth.

4. *Hypsocormus tenuirostris*, sp. nov.

The second species of *Hypsocormus* in Mr. Leeds' collection is represented by an imperfect snout, associated with a right maxilla and portions of splenial and dentary bones (No. 40). The original fish must have attained only about half the size of the typical specimen of *H. Leedsi*; and it is readily distinguished by the narrow, somewhat elongated, and acutely pointed form of the snout, which, however, exhibits the characteristic superficial granulations. The pair of tusk-like teeth is placed relatively further backwards than in *H. macrodon* and *H. Leedsi*, and seems to have been directed more nearly vertically than in the latter species; so far as can be ascertained, a single irregular series of teeth of small size also occupies the margin of either side, being accompanied only by few minute teeth. The maxilla is very slender, externally tuberculated, and provided with a single series of teeth of moderate size, well-spaced and nearly uniform, and flanked externally by a few minute teeth; the anterior end of the bone terminates in a stout, smooth projection, slightly directed inwards. The portions of dentary bones are somewhat broken, but this element is stouter and larger than the maxilla, provided with a single spaced series of much larger teeth, irregular in size, the most powerful being situated in the front portion of the posterior half of the bone; a cluster of minute teeth also occupies the whole of the external margin. As in the other species of *Hypsocormus*, all the teeth are oval or round in section, not keeled, though more or less vertically striated; and the enamelled apex often occupies less than half of the exserted portion.

So far as can be ascertained from the foregoing specimens, there is a singular resemblance between the dentition of *Hypsocormus* and that of the long-snouted *Protosphyræna* of the Upper Cretaceous. In the last-named genus there are two great upper teeth at the base of the snout,[1] while two equally large teeth occur on either side of the lower jaw near its anterior extremity; the latter, moreover, are similarly fixed in a short stout, lenticular splenial bone immediately behind the mandibular symphysis.[2]

It may be added that the genus *Hypsocormus* also occurs in the Kimmeridge Clay of Weymouth, portions of jaws being preserved in the British Museum (No. 42,368).

5. *Leedsichthys problematicus*, gen. et sp. nov.

For some years Mr. Alfred N. Leeds, of Eyebury, has obtained

[1] W. Davies, Geol. Mag. Dec. II. Vol. V. (1878), Pl. VIII. Fig. 3.
[2] F. Dixon, "Geol. and Foss. Sussex" (1850), pl. xxxi. fig. 12.

from the Oxford Clay of the neighbourhood of Peterborough a number of large bones of fibrous texture, and often of indefinite form, pertaining to some hitherto unknown extinct vertebrate. The flatter bones were considered by Mr. Hulke, in 1887, as not improbably referable to the dermal armature of a Dinosaur;[1] but, on visiting the collection in 1888, Prof. Marsh expressed the opinion that the remains were piscine, being unlike any of the numerous types of Dinosaurian dermal armour met with in America. At the beginning of the present year,[2] the writer of this note mentioned the possibility of these fossils indicating the presence of a large Acipenseroid fish in the Upper Jurassic rocks; and it is proposed in the following pages briefly to discuss the few facts already available for consideration. One set of bones undoubtedly pertains to a single individual, and is thus of great value; but many of the fragments are scattered, and, if the interpretations now to be suggested prove correct, the axial skeleton of the trunk still remains to be discovered. No known specimens exhibit any traces of superficial ornamentation, and, though often massive, all the elements have the characteristic fibrous texture of fish-bone.

The associated series of bones just mentioned was spread over an area of probably not less than twelve square yards, and the principal specimens may be enumerated and determined as follows:

1. A large, oblong, flattened bone, of the kind already described by Mr. Hulke. It measures 2 ft. (0·61 m.) in length by 1 ft. 3in. (0·38 m.) in maximum breadth, is of a squamous character, thinning at each margin, and consists of two thin hard layers separated by a middle layer of soft diploë. In form and characters the bone is very suggestive of a *frontal* element.

2. An elongated bone, 1 ft. 8in. (0·58 m.) in length, somewhat broader at one extremity than at the other. One long margin is thickened and rounded, while the other is a thin edge; and the broader extremity is thicker than the narrower. This may perhaps be identified as *angular*.

3. An elongated bone, 1 ft. 3in. (0·38 m.) in length, and the broader extremity of the corresponding element of the opposite side. This is probably the *hyomandibular*. The supposed upper extremity is somewhat expanded, and near this end on the posterior outer margin is a small facette, evidently for the operculum. For two-thirds of its width the bone is thick, but the anterior third is thin, as is also the inferior extremity.

4. Portions of four long narrow bones, the largest being 2 ft. 5in. (0·735 m.) in length, and not more than $3\frac{1}{2}$ in. (0·09 m.) in maximum width. Each bone is comparatively hard, irregularly ≺-shaped in transverse section, and seems most nearly paralleled by the ossifications of the *branchial arches* in Teleosteans.

5. A very large number of small, narrow, elongated bones of peculiar shape, probably to be regarded as *gill-rakers*. The largest

[1] J. W. Hulke, "Note on some Dinosaurian Remains in the Collection of A. Leeds, Esq.," Quart. Journ. Geol. Soc., vol. xliii. (1887), p. 702.

[2] Smith Woodward, "On the Palæontology of Sturgeons," Proc. Geol. Assoc., vol. xi. (1889), p. 31.

of these are about 3in. (0·075 m.) in length, and ⅛in. (0·010m.) in width. Each is laterally compressed, slightly expanded at one extremity, and rarely straight, but irregularly bent or contorted. The surface is coarsely rugose, and one long border is rounded, while the other is cleft by a longitudinal median furrow. The rounded border is comparatively smooth, but the furrowed edge is coarsely serrated, a series of short oblique ridges terminating in points on each side.

6. Portion of a large squamous bone, longer (deeper) than broad, with one long margin thickened, rounded, and concavely arched. A nearly complete example of the same element, doubtfully forming part of the series, measures 2ft. 9in. (0·838m.) in length, and suggests that it may be identified either with the *preoperculum* or *clavicle*.

7. Portions of eleven very dense, large, rib-shaped bones, only superficially ossified at the broader extremity, but terminating in a well-formed point at the distal end. These bones are rounded or irregularly quadrangular in section, are more or less arched, and vary considerably in relative width or thickness. The broadest and stoutest specimen is much arched, 1ft. 5in. (0·43 m.) in length; and a nearly perfect detached example of the same bone shows that this wants a length of at least 8in (0·23 m.) at the pointed extremity. The largest bone measures 2ft. 4in. (0·712 m.) in length, and is straightened; while the smaller examples are more curved and more rounded in section. These bones were evidently arranged in not less than six pairs, and Mr. Leeds' suggestion seems most plausible, that they are the *branchiostegal rays* of the fish.

8. The *fin-rays* are most remarkable, and, judging from the position in which they were discovered, the known specimens may all probably be assigned to the pectoral fin. They consist of fibrous bone, and appear as if composed of numerous long, tapering bony splints, incompletely fused together. The two halves of each ray remain separate, and in some cases they have been proved to attain a length of not less than 5ft. (1·525 m.). There are no transverse joints, but all the rays exhibit numerous bifurcations, and Mr. Leeds estimates that the distal extremity of each of the largest becomes divided into at least thirty-two small branches.

Smaller more slender fin-rays, probably of the same type of fish, have also been discovered in the Oxford Clay of the same locality. These are gently rounded and transversely articulated, thus suggesting that the specimens just noticed are characteristic only of a powerful pectoral.

As already mentioned, many other detached bones, undoubtedly of the same genus and species, occur in Mr. Leeds' collection; but, of the elements not described above, the form is so indefinite as to render their determination very uncertain. If, however, the few suggestions here propounded are eventually confirmed, it is obvious that many hard parts of the fish still remain to be discovered. No known fish with ossifications of the branchial arches and branchiostegal membrane of the kind here described is destitute of at least some ossifications in the axial skeleton of the trunk; and it will be strange, indeed, if a monster with such powerful pectoral fins does

not prove to have been possessed of a formidable dentition. It is satisfactory to know that there is good reason to hope for the discovery of much more of the skeleton of the individual discussed above, as soon as the bed where it occurs is worked again; and Mr. Leeds is fortunately acquainted with the precise stratum where the specimen occurs.

The characters of the gill-rakers, branchiostegal rays, and pectoral fin-rays, taken together, justify the definite separation of the fish in question from all known generic types; and it is proposed to apply to it the name of *Leedsichthys* in honour of its discoverer. The Peterborough species may be provisionally termed *Leedsichthys problematicus*, and it is probably the most gigantic Jurassic fish hitherto described.

A group of the characteristic gill-rakers, of equally large size, has also been obtained from the Oxford Clay of Vaches Noires (Brit. Mus. No. 32,581), thus indicating the occurrence of the genus in the Upper Jurassic of the North of France.

6. *Mesodon.*

The genus *Pycnodus*, as now defined, is restricted to the Eocene formations, and all the British Mesozoic fossils originally described under that name are to be distributed among the more precisely defined genera determined on the continent. This is a difficult task, so far as the Jurassic species are concerned, for little more than detached examples of jaws and teeth are known, and there is apparently considerable variation in these parts. The so-called *Pycnodus pagoda*, Blake,[1] from the Portlandian, is evidently a vomer of *Microdon*; but nearly all the other described British Jurassic "species" of *Pycnodus* pertain to *Mesodon*. Fricke, v. Zittel, and others, have already pointed out that to this genus may be referred the Agassizian species *P. Bucklandi*, *P. ovalis*, and *P. rugulosus*, and to the synonymy of the first we would add *P. didymus*, Ag., *P. obtusus*, Ag., and *Gyrodus perlatus*, Ag. The latter name is given to some detached scales from the Stonesfield Slate, ornamented by tubercles instead of rugosities or pits, thus being truly referable to *Mesodon*, and agreeing sufficiently in size with the associated jaws of *M. Bucklandi* to be provisionally ascribed to that form. To *M. rugulosus* we would also assign the undescribed *Pycnodus parvus*, Ag., of which a specimen marked as "type" is in the Egerton Collection. Some so-called species of *Gyrodus*, e.g. *G. trigonus*, Ag., are also most probably referable to the same genus; and the Liassic *Pycnodus liassicus*, Egert., was long ago placed in *Mesodon* by Heckel.

7. *Thrissops.*

Since the researches of Agassiz, Münster, Wagner, and Thiollière, so many Jurassic examples of the genus *Thrissops* have been acquired by various Museums, that it would be interesting to study the characters of the specific types already determined in the light of the new material before making any further additions to the

[1] J. F. Blake, "On the Portland Rocks of England," Quart. Journ. Geol. Soc., vol. xxxvi. (1880), p. 228, pl. x. fig. 10.

nomenclature of the group. In recording the occurrence of the genus in the English Jurassic, it must therefore suffice to remark that the British Museum possesses characteristic remains of a species as large as *T. Heckeli*, Thioll.,[1] from the Kimmeridge Clay of Dorsetshire (B.M. Nos. P. 922, P. 3686, P. 6031); while a nearly complete example of a much smaller species has been obtained from the Portland Stone of the Isle of Portland (B.M. No. P. 5538).

8. *Browneichthys ornatus*, gen. et sp. nov.

In the series of vertebrate fossils from the Lower Lias of Barrow-on-Soar, recently obtained for the Leicester Museum by Mr. Montagu Browne, F.Z.S., is an interesting small fish, apparently of a new generic type, which the present writer has been favoured with the privilege of examining. The specimen is only about 0·06 in length, displaying portions of the head and trunk; but, notwithstanding its imperfections, it seems worthy of brief notice as being so different from anything hitherto known. The fish must have been originally elongated in form; and the hinder portion of the head, preserved as far forwards as the front margin of the orbit, suggests the attenuation of the snout. The space occupied by the notochord is vacant, indicating its persistence, but the neural and hæmal arches are well ossified superficially, and there is no evidence of elongated, well-developed ribs. The bones of the head are invested with ganoine, and ornamented with large tuberculations; and at least the front portion of the trunk is covered with thin, deeply-overlapping scales, oval or round in shape, with prominent concentric lines of growth, and externally ornamented with large ganoine tubercles. Three or four relatively large, narrow, pointed ridge-scales, above and below, also indicate a partial or continuous armature of the dorsal and ventral margins. Of the dentition and the fins, nothing can be ascertained from the fossil now described; and although a series of eight slender bones shortly behind the occiput may possibly be the interspinous bones of a dorsal fin, it will be well to await the discovery of other specimens before attempting their interpretation.

So far as can be determined, the new Barrow fossil thus most nearly approaches the early Mesozoic Ganoids, *Belonorhynchus* and *Saurichthys*. From these, however, and from other types with a persistent notochord, it is generically distinguished by the squamation; and employing the discoverer's name, the new form may be termed *Browneichthys*. The type-species may be known as *B. ornatus*.

IV.—An Analysis of The Fullers Earth of Nutfield.

By P. Gerald Sanford, F.I.C., F.C.S.,
Royal School of Mines, London.

DURING June last I visited the Fullers Earth Pits at Nutfield, near Redhill, Surrey, with the London Geological Field Class, when Professor Seeley suggested to me that I should make an

[1] V. Thiollière, "Poiss. Foss. Bugey," pt. i. (1854), p. 27, pl. x. fig. 1.

analysis of the deposit. This I have been enabled to do through the kindness of the manager (A. Sheridan, Esq.), who was good enough to send me a series of samples of the earth, and the various products prepared from it. The Nutfield Fullers Earth is a heavy blue or yellow clay, with a greasy feel and an earthy fracture. The sample No. 1 contained 27·47 per cent. and No. 2, 29·56 per cent. of water before drying.

No. 1. Blue Earth.

Dried at 100° C				Insoluble Residue.		
Insoluble Residue	=	59·96 per cent.	=	SiO_2	=	52·81 per cent.
Iron (Fe_2O_3)	=	2·48		Al_2O_3	=	3·46 ,,
Alumina (Al_2O_3)	=	3·46		Fe_2O_3	=	1·30 ,,
Lime, CaO	=	5·87		CaO	=	1·53 ,,
Magnesia, MgO	=	1·41		MgO	=	0·86 ,,
Phosphoric acid, P_2O_5	=	0·27	Soluble			
Sulphuric acid, SO_3	=	0·05	in acid.			59·96
Sodic chloride, NaCl	=	0·05				
Alkalies, K_2O	=	0·74				
Combined water	=	14·27				

No. 2. Yellow Earth.

Dried at 100° C				Insoluble Residue.		
Insoluble Residue	=	76·13 per cent.	=	Silica	=	59·37 per cent.
Iron, Fe_2O_3	=	2·41		Al_2O_3	=	10·05 ,,
Alumina	=	1·77		Fe_2O_3	=	3·86 ,,
Lime, CaO	=	4·31		CaO	=	1·86 ,,
Magnesia, MgO	=	1·05		MgO	=	1·04 ,,
P_2O_5	=	0·14	Soluble			
SO_3	=	0·07	in acid.			76·18
Salt, NaCl	=	0·14				
Alkalies, K_2O	=	0·84				
Combined water	=	13·19				
		100·05				

V.—Analysis of the Gault and Greensand.

By P. Gerald Sanford, F.I.C., F.C.S.,

Metallurgical Laboratory, Royal School of Mines.

THE sample of Gault, of which the analysis is given below, was obtained from the Clay Pits at Dunton Green, which I visited with the "London Geological Field Class" during June last. At this place the Gault rests upon a bed of reddish yellow sand (Lower Greensand), which is mixed in certain proportions with the Gault clay to form bricks. This sand, of which I also give an analysis, is very moist when first taken from the bed, but very rapidly becomes dry, upon exposure to the air, so that it afterwards loses very little more water at 100°C. The Gault, as taken from the pit, contained 26·68 per cent of moisture, but upon ignition of the dried substance, in a muffle furnace, it becomes so hard that it will scratch glass easily.

Analysis of Gault.

	Dried at 100°C.		Insoluble Residue.	
Insoluble Residue	= 65·01 per cent =	Silica, SiO_2	= 46·43 per. cent.	
Ferric oxide, Fe_2O_3	= 7·92	Fe_2O_3	= 2·05	,,
Alumina, Al_2O_3	= 3·40	Al_2O_3	= 15·41	,,
Maganese oxide, MnO.	= trace	CaO	= 0·88	,,
Lime, CaO	= 5·90	MgO	= 0·24	,,
Magnesia, MgO	= 0·75			
Sodium chloride	= 0·05 Soluble		65·01	
Phosphoric acid, P_2O_5	= 0·11 in acid.			
Sulphuric acid, SO_3	= 0·19			
Carbonic acid, CO_2	= 6·09			
K_2O, and Na_2O	= 0·07			
Combined water	= 10·48			
	99·97			

Analysis of Greensand.

	Dried at 100°C.	
Silica, SiO_2 ...	= 98·80 per cent.	
$Fe_2O_3 + Al_2O_3$	= 0·47	
Lime, CaO	= 0·09	Soluble in acid.
Magnesia, MgO	= 0·05	
Sulphuric acid, SO_3	= trace	
Combined water	= 0·42	
	99·83	

NOTICES OF MEMOIRS.

D. Stur on British Coal-Plants.

I.—Momentaner Standpunkt meiner Kenntniss über die Steinkohlenformation Englands. Von D. Stur. Jahrbuch der k. k. Geolog. Reichsanstalt, 1889, Bd. xxxix. 1 u. 2 Heft. pp. 1–20.

HERR D. STUR, the Director of the Geological Survey of Austria, took advantage of his visit to the International Geological Congress last year, to study in the field and in some of the principal museums, the flora of the British Carboniferous strata, and the present paper contains in a condensed form the results of his observations and his views of the relative age of our different coal-fields, as compared with the beds on the Continent, and more particularly with those of the Moravian-Bohemian-Silesian area. The following are the conclusions arrived at by the author:—

I. In Britain, the first or oldest Culm-flora of the Culm-roofing shales, specially occurs in the great Scotch basin, in the Burdie-House limestones, in the Carboniferous shale of Slateford, and in the Calciferous sandstone. In Devonshire, on the other hand, the Culmdackschiefer is represented by the "Lower Culm-measures" near Bideford, whilst the "Upper Culm-measures" belong to the Lower Carboniferous, and are identical with the Schatzlarer beds.

II. The second Culm-flora, or that of the Ostrauer beds, is probably quite absent in England, and not a single characteristic species was

met with. It is probable that the great band of the Millstone-grit, which in the Pennystone and Barnsley district is beneath the horizon of the Schatzlarer beds, may represent the Ostrauer deposits, and in this case the second Culm-flora might be looked for in the thin Coal-seams occasionally occurring in the Millstone-grit. It is further possible that the Coal-measures of the Scotch basin may correspond with the Silesian Ostrauer beds.

III. The greater part of the coals obtained in England are from the horizon of the Schatzlarer beds. To this horizon belong the Coal-areas of Newcastle-on-Tyne, Leeds, Pontefract, Barnsley, Sheffield, Derby, Leicester, Dudley, Coalbrook-Dale, Newcastle-under-Lyme, Manchester, Oldham, Lancaster, and of Whitehaven and Wigton.

IV. The Upper Carboniferous horizon of the Bohemian Rossitzer beds occurs in England in the area of the Bristol Channel, near Bristol and Radstock, and in the vicinity of Merthyr Tydvil, over Swansea to Caermarthen; and more to the north the Coal-fields of the Forest of Dean, the Forest of Wyre and near Wigan, belong to this same Upper Carboniferous horizon.

V. It is remarkable that up to the present no trace of the presence of this Upper Carboniferous horizon has been met with to the east of the great band of Millstone-grit, and in this respect there is a striking correspondence with the Coal-fields of Westphalia, Belgium and Northern France, which belong to the Schatzlarer horizon, and in which the Upper Carboniferous Rossitzer beds are not represented.

VI. The Upper Carboniferous, on the other hand, occurs in Central France, Bohemia and Saxony, also in Banate, and frequently unconformably on much older strata. Thus, also in the line from Swansea, Bristol, Forest of Dean to Shrewsbury the Upper Carboniferous beds are in places unconformably deposited on older strata.

VII. Further, there is in England no trace of the horizon of the Schwadowitzer beds of north-eastern Bohemia, of the Saxon beds of Oberhohndorf near Zwickau, nor of the Radnitzer and Zemech beds. These horizons may probably be looked for where the beds of Schatzlarer approach those of the Upper Carboniferous, as at Wigan and at Coalbrook-Dale.

VIII. It may be concluded from the absence of particular beds in the Carboniferous series of England, France, Belgium and Westphalia, that great changes in the configuration of the land took place during the deposition of the Coal and its associated beds; that they were by no means continuously laid down; and that the changes in the flora of the individual horizons indicate enormously prolonged intervals of time for their production.

The author further adds short critical notices of the more important species of fossil plants in the Hutton Collection, now preserved in the Museum at Newcastle-on-Tyne.

II.—The Geology of London and of Part of the Thames Valley. By William Whitaker, F.R.S.

UNDER the above title there has just been published a Geological Survey Memoir (in two volumes), which gives a very full and detailed account of the geology of the district. Vol. i. Descriptive Geology, pp. xii. 556, folding table, price 6*s.*; and vol. ii. Appendices (well-sections, etc.), pp. iv. 352, price 5*s.* We hope in a future number, after H.M. Government has presented us with a review-copy, to give some account of this important work, which, to say the least of it, offers a large amount of material for study and for reference at an unusually low (official) price.

REVIEWS.

The Ganoids of the German Muschelkalk. "Die Ganoiden des deutschen Muschelkalks." By Prof. Dr. W. Dames. Palæontologische Abhandlungen, Band IV. Heft 2 (1888), pp. 133–180, pls. xi.–xvi*a*.

TO any one accustomed to the writings of Agassiz, Count von Münster, H. von Meyer, and others, upon the fossil fish remains of the Muschelkalk, Prof. Dames' memoir will come as a pleasant surprise. Instead of a series of scattered teeth and scales, the Professor has brought together from various museums a number of valuable specimens affording some real insight into the characters of the Mid-Triassic Ganoids; and the detailed descriptions and discussion of these fossils are illustrated by seven fine plates. The specimens were almost exclusively obtained from the extra-Alpine Muschelkalk, and are referable to the genera *Gyrolepis*, Agassiz; *Colobodus*, Agassiz; *Crenilepis*, Dames; and *Serrolepis*, Quenstedt.

The reference of *Gyrolepis* to the Palæoniscidæ is confirmed by several fine fossils, and a definition of the genus can at last be attempted. The mandibular suspensorium is very oblique, and the operculum extremely elongated vertically; the teeth are long, slender, and conical; the dorsal fin is smaller than the anal, and situated opposite or in advance of this; there are small fulcra upon each of the fins; most of the pectoral fin-rays are not articulated; and the two infraclaviculars are fused together. This genus is the only Palæoniscid yet described from the European Trias, and Prof. Dames recognizes four species, as follows: *G. Agassizii* (Münster), and *G. ornatus* (Giebel), from the Lower Muschelkalk, *G. Albertii*, Agassiz, from the Upper Muschelkalk, and *G. Quenstedti*, Dames, from the Lettenkohle.

Gyrolepis Agassizii has until now been assigned either to *Amblypterus* or *Rhabdolepis*; but a comparison of the well-preserved type-specimen with more recently discovered examples of *Gyrolepis* proper definitely decides its generic position, and the characters of the scale-ornament determine its specific distinctness. *G. ornatus* has also been hitherto referred to *Amblypterus*, and the type-specimen, now figured for the first time, remains unique. *G. Albertii* is no longer

known merely from detached scales, but is represented by the anterior portion of a fish and two examples of the head; and Dr. Dames points out that some of the scales have been named *G. maximus*, Ag., and *G. tenuistriatus*, Ag. *G. Quenstedti* is a new species, founded upon the hinder portion of a fish, remarkable for the great length of the anal fin and the comparatively remote situation of the dorsal.

The genus *Colobodus* proves to be a Lepidosteoid Ganoid related to *Lepidotus*, and having no connection with the Pycnodonts, to which it is commonly assigned. It differs from *Lepidotus*, so far as known, in the presence of an apical tubercle upon the rounded teeth, in the prominence of the scale-ornament, and in the depressed form of the head. Considerable variation, however, is exhibited in the five recognized species; and while relegating *Dactylolepis*, *Nephrotus*, and *Asterodon* to the synonymy, Dr. Dames suspects that future discoveries may possibly justify the retention of the two first-mentioned names for the peculiar species to which they were originally applied. The fins and the precise form of the trunk are still unknown in all the species: but tolerably complete specimens of the squamation and dentition are described, and these lead to a considerable reduction in the number of "species" based upon isolated scales and teeth.

A new genus and species, *Crenilepis Sandbergeri*, is founded upon a well-preserved portion of the squamation of a large fish from the Upper Muschelkalk of Krainberg, evidently related to the earlier Lepidosteoids, and distinguished by the form and ornamentation of the scales. In the anterior part of the flank, the scales are very much deeper than broad; and those of all parts are externally sculptured with a number of delicate branching furrows.

The type-species of the genus *Serrolepis*, Quenstedt, from the Lettenkohle, is now named *S. suevicus*; but only scattered scales are known, and Dames doubtfully associates with this fish a fragment of jaw, with stout styliform teeth, discovered upon the same slab of stone. On the whole, the genus seems most probably allied to *Dapedius*.

In conclusion, Dr. Dames discusses an interesting problematical fish from the Upper Muschelkalk of Brunswick, not yet determinable, but in some respects suggestive of close relationship with the Semionotidæ. A summary of results then follows, and it is interesting to note how the distribution of species of Ganoids in the Muschelkalk agrees well with that of the Crinoids and the Cephalopods, the Lower, Middle, and Upper divisions being distinctly separated, and also the overlying Lettenkohle.

A brief appendix records the occurrence of other well-preserved Ganoids in the same formation, including probably a new Palæoniscid genus, a new species of *Gyrolepis*, and a fish allied to *Pholidophorus*. These, and any other materials with which the author may be favoured, will form the subject of a second memoir to which we look forward with considerable interest. A. S. W.

REPORTS AND PROCEEDINGS.

Fifty-ninth Annual Meeting of the British Association for the Advancement of Science.

Newcastle-upon-Tyne, 1889.

Address to the Geological Section of the British Association. By Professor James Geikie, LL.D., F.R.SS. L. & E., F.G.S., President of the Section, September 12th, 1889.

After some introductory remarks, Prof. James Geikie said: Perhaps there is no department of geological inquiry that has given rise to more controversy than that of Glacial Geology, which I have selected for the subject of this address. Hardly a single step in advance has been taken without vehement opposition. But the din of contending sides is not so loud now—the dust of the conflict has to some extent cleared away, and the positions which have been lost or maintained, as the case may be, can be readily discerned. The glacialist who can look back over the last twenty-five years of wordy conflict has every reason to be jubilant and hopeful. Many of those who formerly opposed him have come over to his side. It is true he has not had everything his own way. Some extreme views have been abandoned in the struggle; that of a great polar ice-sheet, for example, as conceived by Agassiz. I am not aware, however, that many serious students of Glacial Geology ever adopted that view. But it was quite an excusable hypothesis, and has been abundantly suggestive. Had Agassiz lived to see the detailed work of these later days, he would doubtless have modified his notion, and come to accept the view of large continental glaciers which has taken its place.

The results obtained by geologists, who have been studying the peripheral areas of the drift-covered regions of our continent, are such as to satisfy us that the drifts of those regions are not iceberg-droppings, as we used to suppose, but true morainic matter and fluvio-glacial detritus. Geologists have not jumped to this conclusion—they have only accepted it after laborious investigation of the evidence. Since Dr. Otto Torell, in 1875, first stated his belief that the "diluvium" of North Germany was of glacial origin a great literature on the subject has sprung up, a perusal of which will show that with our German friends Glacial Geology has passed through much the same succession of phases as with us. At first icebergs are appealed to as explaining everything—next we meet with sundry ingenious attempts at a compromise between floating-ice and a continuous ice-sheet. As observations multiply, however, the element of floating-ice is gradually eliminated, and all the phenomena are explained by means of land-ice and "schmelz-wasser" alone. It is a remarkable fact that the iceberg hypothesis has always been most strenuously upheld by geologists whose labours have been largely confined to the peripheral areas of drift-covered countries. In the upland and mountainous tracts, on the other hand,

that hypothesis has never been able to survive a moderate amount of accurate observation. Even in Switzerland—the land of glaciers—geologists at one time were of opinion that the Boulder-clays of the low grounds had a different origin from those which occur in the mountain-valleys. Thus it was supposed that at the close of the Pleistocene period the Alps were surrounded by great lakes or gulfs of some inland sea, into which the glaciers of the high valleys flowed and calved their icebergs—these latter scattering erratics and earthy débris over the drowned areas. Sartorius von Waltershausen[1] set forth this view in an elaborate and well-illustrated paper. Unfortunately for his hypothesis, no trace of the supposed great lakes or inland sea has ever been detected—on the contrary, the character of the morainic accumulations, and the symmetrical grouping and radiation of the erratics and perched blocks over the foot-hills and low grounds, show that these last have been invaded and overflowed by the glaciers themselves. Even the most strenuous upholders of the efficacy of icebergs as originators of some Boulder-clays admit that the Boulder-clay or till, of what we may call the inner or central region of a glaciated tract, is the product of land-ice. Under this category comes the Boulder-clay of Norway, Sweden, and Finland, and of the Alpine lands of Central Europe, not to speak of the hilly parts of our own islands.

When we come to study the drifts of the peripheral areas it is not difficult to see why these should be considered to have had a different origin. They present certain features which, although not absent from the glacial deposits of the inner region, are not nearly so characteristic of such upland tracts. I refer especially to the frequent interstratification of Boulder-clays with well-bedded deposits of clay, sand, and gravel; and to the fact that these Boulder-clays are often less compressed than those of the inner region, and have even occasionally a somewhat silt-like character. Such appearances do seem at first to be readily explained on the assumption that the deposits have been accumulated in water opposite the margin of a continental glacier or ice-sheet—and this was the view which several able investigators in Germany were for some time inclined to adopt.

But when the phenomena came to be studied in greater detail, and over a wider area—this preliminary hypothesis did not prove satisfactory. It was discovered, for example, that "giants' kettles"[2] were more or less commonly distributed under the glacial deposits, and such "kettles" could only have originated at the bottom of a glacier. Again it was found that pre-Glacial accumulations were plentifully developed in certain places below the drift, and were often involved with the latter in a remarkable way. The "brown-coal-formation" in like manner was violently disturbed and displaced, to such a degree that frequently the Boulder-clay is found to underlie

[1] Untersuchungen über die Klimate der Gegenwart und der Vorwelt, etc. Natuurkundige Verhandelingen v. d. Holland. Maatsch. d. Wetensch. te Haarlem, 1865

[2] These appear to have been first detected by Professor Berendt and Professor E. Geinitz.

it. Similar phenomena were encountered in regions where the drift underlies the Chalk—the latter presenting the appearance of having been smashed and shattered—the fragments having often been dragged some distance, so as to form a kind of friction-breccia underlying the drift, while large masses are often included in the clay itself. All the facts pointed to the conclusion that these disturbances were due to tangential thrusting or crushing, and were not the result of vertical displacements, such as are produced by normal faulting, for the disturbances in question die out from above downwards. Evidence of similar thrusting or crushing is seen in the remarkable faults and contortions that so often characterize the clays and sands that occur in the Boulder-clay itself. The only agent that could produce the appearances now briefly referred to is land-ice, and we must therefore agree with German geologists that glacier-ice has overflowed all the drift-covered regions of the peripheral area. No evidence of marine action in the formation of the stony clays is forthcoming—not a trace of any sea-beach has been detected. And yet, if these clays had been laid down in the sea during the retreat of the ice-sheet from Germany, surely such evidence as I have indicated ought to be met with. To the best of my knowledge the only particular facts which have been appealed to, as proofs of marine action, are the appearance of bedded deposits in the Boulder-clays, and the occasional occurrence in the clays themselves of a sea-shell. But other organic remains are also met with now and again in similar positions, such as mammalian bones and fresh-water shells. All these, however, have been shown to be derivative in their origin—they are just as much erratics as the stones and boulders with which they are associated. The only phenomena, therefore, that the glacialist has to account for are the bedded deposits which occur so frequently in the Boulder-clays of the peripheral regions, and the occasional silty and uncompressed character of the clays themselves.

The intercalated beds are, after all, not hard to explain. If we consider for a moment the geographical distribution of the Boulder-clays, and their associated aqueous deposits, we shall find a clue to their origin. Speaking in general terms the stony clays thicken out as they are followed from the mountainous and high-lying tracts to the low ground. Thus they are of inconsiderable thickness in Norway, the higher parts of Sweden, and in Finland, just as we find is the case in Scotland, Northern England, Wales, and the hilly parts of Ireland. Traced south from the uplands of Scandinavia and Finland, they gradually thicken out as the low grounds are approached. Thus in Southern Sweden they reach a thickness of 43 metres or thereabout, and of 80 metres in the northern parts of Prussia, while over the wide low-lying regions to the south they attain a much greater thickness—reaching in Holstein, Mecklenburg, Pomerania, and West Prussia a depth of 120 to 140 metres, and still greater depths in Hanover, Mark Brandenburg, and Saxony. In those regions, however, a considerable portion of the "diluvium" consists, as we shall see presently, of water-formed beds.

The geographical distribution of the aqueous deposits which are associated with the stony clays is somewhat similar. They are very sparingly developed in districts where the Boulder-clays are thin. Thus they are either wanting, or only occur sporadically in thin irregular beds, in the high grounds of Northern Europe generally. Further south, however, they gradually acquire more importance until in the peripheral regions of the drift-covered tracts they come to equal and eventually to surpass the Boulder-clays in prominence. These latter, in fact, at last cease to appear, and the whole bulk of the "diluvium" along the southern margin of the drift area appears to consist of aqueous accumulations alone.

The explanations of these facts advanced by German geologists are quite in accordance with the views which have long been held by glacialists elsewhere, and have been tersely summed up by Dr. Jentzsch.[1] The northern regions, he says, were the feeding-grounds of the inland ice. In those regions melting was at a minimum, while the grinding action of the ice was most effective. Here, therefore, erosion reached its maximum—ground-moraine or Boulder-clay being unable to accumulate to any thickness. Further south, melting greatly increased, while ground-moraine at the same time tended to accumulate—the conjoint action of glacier-ice and sub-Glacial water resulting in the complex drifts of the peripheral area. In the disposition and appearance of the aqueous deposits of the "diluvium" we have evidence of an extensive sub-Glacial water-circulation—glacier-mills that gave rise to "giants' kettles"—chains of sub-glacial lakes in which fine clays gathered—streams and rivers that flowed in tunnels under the ice, and whose courses were paved with sand and gravel. Nowhere do German geologists find any evidence of marine action. On the contrary, the dove-tailing and interosculation of Boulder-clay with aqueous deposits are explained by the relation of the ice to the surface over which it flowed. Throughout the peripheral area it did not rest so continuously upon the ground as was the case in the inner region of maximum erosion. In many places it was tunnelled by rapid streams and rivers, and here and there it arched over sub-Glacial lakes, so that accumulation of ground-moraine proceeded side by side with the formation of aqueous sediments. Much of that ground-moraine is of the usual tough and hard-pressed character, but here and there it is somewhat less coherent and even silt-like. Now a study of the ground-moraines of modern glaciers affords us a reasonable explanation of such differences. Dr. Brückner[2] has shown that in many places the ground-moraine of Alpine glaciers is included in the bottom of the ice itself. The ground-moraine, he says, frequently appears as an ice-stratum abundantly impregnated with silt and rock-fragments—it is like a conglomerate or breccia which has ice for its binding material. When this ground-moraine melts out of the ice—no running water being present—it forms a layer of unstratified silt or

[1] Jahrb. d. königl. preuss. geologischen Landesanstalt für 1884, p. 438.

[2] Die Vergletscherung des Salzachgebietes, etc.: Geographische Abhandlungen herausgegeben v. A. Penck, band i. heft 1.

clay, with stones scattered irregularly through it. Such being the case in modern glaciers, we can hardly doubt that over the peripheral areas occupied by the old northern ice-sheet Boulder-clay must frequently have been accumulated in the same way. Nay, when the ground-moraine melted out and dropped here and there into quietly-flowing water, it might even acquire in part a bedded character.

The limits reached by the inland ice during its greatest extensions are becoming more and more clearly defined, although its southern margin will probably never be so accurately determined as that of the latest epoch of general glaciation. The reasons for this are obvious. When the inland ice flowed south to the Harz and the hills of Saxony it formed no great terminal moraines. Doubtless many erratics and much rock-rubbish were showered upon the surface of the ice from the higher mountains of Scandinavia, but owing to fanning-out of the ice on its southward march such superficial débris was necessarily spread over a constantly widening area. It may well be doubted, therefore, whether it ever reached the terminal front of the ice-sheet in sufficient bulk to form conspicuous moraines. It seems most probable that the terminal moraines of the great inland ice would consist of low banks of Boulder-clay and aqueous materials —the latter, perhaps, strongly predominating, and containing here and there larger and smaller angular erratics which had travelled on the surface of the ice. However that may be, it is certain that the whole region in question has been considerably modified by subsequent denudation, and to a large extent is now concealed under deposits belonging to later stages of the Pleistocene period. The extreme limits reached by the ice are determined rather by the occasional presence of rock striæ and *roches moutonnées*, of Boulder-clay and northern erratics, than by recognizable terminal moraines. The southern limits reached by the old inland ice appear in this way to have been tolerably well ascertained over a considerable portion of Central Europe. Some years ago I published a small sketch-map[1] showing the extent of surface formerly covered by ice. On this map I did not venture to draw the southern margin of the ice-sheet in Belgium further south than Antwerp, where northern erratics were known to occur; but the more recent researches of Belgian geologists show that the ice probably flowed south for some little distance beyond Brussels.[2] Here and there in other parts of the Continent the southern limits reached by the northern drift have also been more accurately determined, but so far as I know, none of these later observations involves any serious modifications of the sketch-map referred to.

I have now said enough, however, to show that the notion of a general ice-sheet having covered so large a part of Europe, which a few years ago was looked upon as a wild dream, has been amply justified by the labours of those who are so assiduously investigating the peripheral areas of the "great northern drift." And perhaps I may be allowed to express my own belief that the drifts of Middle and

[1] Prehistoric Europe, 1881.

[2] See a paper by M. E. Delvaux, Ann. de la Soc. géol. de Belg. t. xiii. p. 158.

Southern England, which exhibit the same complexity as the "lower diluvium" of the Continent, will eventually be generally acknowledged to have had a similar origin. I have often thought that whilst politically we are happy in having the sea all round us, geologically we should have gained perhaps by its greater distance. At all events we should have been less ready to invoke its assistance to explain every puzzling appearance presented by our glacial accumulations.

I now pass on to review some of the general results obtained by continental geologists as to the extent of area occupied by inland ice during the last great extension of glacier-ice in Europe. It is well known that this latest ice-sheet did not overflow nearly so wide a region as that underneath which the lowest Boulder-clay was accumulated. This is shown not only by the geographical distribution of the youngest Boulder-clay, but by the direction of rock-striæ, the trend of erratics, and the position of well-marked moraines. Gerard de Geer has given a summary[1] of the general results obtained by himself and his fellow-workers in Sweden and Norway; and these have been supplemented by the labours of Berendt, Geinitz, Hunchecorne, Keilhack, Klockmann, Schröder, Wahnschaffe, and others in Germany, and by Sederholm in Finland.[2] From them we learn that the end-moraines of the ice circle round the southern coasts of Norway, from whence they sweep south-east by east across the province of Gottland in Sweden, passing through the lower ends of Lakes Wener and Wetter, while similar moraines mark out for us the terminal front of the inland ice in Finland—at least two parallel frontal moraines passing inland from Hango Head on the Gulf of Finland through the southern part of that province to the north of Lake Ladoga. Further north-east than this they have not been traced; but, from some observations by Helmersen, Sederholm thinks it probable that the terminal ice-front extended north-east by the north of Lake Onega to the eastern shores of the White Sea. Between Sweden and Finland lies the basin of the Baltic, which at the period in question was filled with ice, forming a great Baltic glacier, which overflowed the Aland Islands, Gottland, and Öland, and which, fanning out as it passed towards the south-west, invaded, on the south side, the Baltic provinces of Germany, while, on the north, it crossed the southern part of Scania in Sweden and the Danish islands to enter upon Jutland.

The Upper Boulder-clay of those regions is now recognized as the ground-moraine of this latest ice-sheet. In many places it is separated from the older Boulder-clay by inter-Glacial deposits, some of which are marine, while others are of fresh-water and terrestrial origin. During inter-Glacial times the sea that overflowed a considerable portion of North Germany was evidently continuous

[1] Zeitschrift d. deutsch. geolog. Ges. Bd. xxvii. p. 177.

[2] For papers by Berendt and his associates see especially the Jahrbuch d. k. preuss. geol. Landesanstalt, and the Zeitschr. d. deutsch. geol. Ges. for the past few years. Geinitz, Forsch. z. d. Landes- u. Volkskunde, i. 5; Leopoldina, xxii. p. 37; I. Beitrag z. Geologie Mecklenburgs, 1880, p. 46, 56; Sederholm, Fennia, i. No. 7.

with the North Sea, as is shown not only by the geographical distribution of the inter-Glacial marine deposits, but by their North Sea fauna. German geologists generally group all the inter-Glacial deposits together, as if they belonged to one and the same inter-Glacial epoch. This perhaps we must look upon as only a provisional arrangement. Certain it is that the fresh-water and terrestrial beds which frequently occur on the same or a lower level and at no great distance from the marine deposits, cannot in all cases be contemporaneous with the latter. Possibly, however, such discordances may be accounted for by oscillations in the level of the inter-Glacial sea—land and water having alternately prevailed over the same area. Two Boulder-clays, as we have seen, have been recognized over a wide region in North Germany. In some places, however, three or more such Boulder-clays have been observed overlying one another throughout considerable areas, and these clays are described as being distinctly separate and distinguishable the one from the other.[1] Whether they with their intercalated aqueous deposits indicate great oscillations of one and the same ice-sheet—now advancing, now retreating—or whether the stony clays may not be the ground-moraines of so many different ice-sheets, separated the one from the other by true inter-Glacial conditions, future investigations must be left to decide.

The general conclusions arrived at by those who are at present investigating the glacial accumulations of Northern Europe may be summarized as follows:

1. Before the invasion of Northern Germany by the inland ice the low grounds bordering on the Baltic were overflowed by a sea which contained a boreal and arctic fauna. These marine conditions are indicated by the presence under the Lower Boulder-clay of more or less well-bedded fossiliferous deposits. On the same horizon occur also beds of sand, containing fresh-water shells, and now and again mammalian remains, some of which imply cold and others temperate climatic conditions. Obviously all these deposits may pertain to one and the same period, or more properly to different stages of the same period—some dating back to a time when the climate was still temperate, while others clearly indicate the prevalence of cold conditions, and are therefore probably somewhat younger.

2. The next geological horizon in ascending order is that which is marked by the "Lower Diluvium"—the Glacial and fluvio-Glacial detritus of the great ice-sheet which flowed south to the foot of the Harz Mountains. The Boulder-clay on this horizon now and again contains marine, fresh-water, and terrestrial organic remains, derived undoubtedly from the so-called pre-Glacial beds already referred to. These latter, it would appear, were ploughed up and largely incorporated with the ground-moraine.

3. The inter-Glacial beds which next succeed contain remains of a well-marked temperate fauna and flora, which point to something more than a mere partial or local retreat of the inland ice. The geographical distribution of the beds and the presence in these of

[1] H. Schröder, Jahrb. d. k. preuss. geol. Landesanstalt für 1887, p. 360.

such forms as *Elephas antiquus, Cervus elephas, C. megaceros*, and a flora comparable to that now existing in Northern Germany, justify geologists in concluding that the inter-Glacial epoch was one of long duration, and characterized in Germany by climatic conditions apparently not less temperate than those that now obtain. One of the phases of that inter-Glacial epoch, as we have seen, was the overflowing of the Baltic provinces by the waters of the North Sea.

4. To this well-marked inter-Glacial epoch succeeded another epoch of arctic conditions, when the Scandinavian inland ice once more invaded Germany, ploughing through the inter-Glacial deposits, and working these up in its ground-moraine. So far as I can learn, the prevalent belief among geologists in North Germany is that there was only one inter-Glacial epoch; but, as already stated, doubt has been expressed whether all the facts can be thus accounted for. There must always be great difficulty in the correlation of widely-separated inter-Glacial deposits, and the time does not seem to me to have yet come when we can definitely assert that all those inter-Glacial beds belong to one and the same geological horizon.

I have dwelt upon the recent work of geologists in the peripheral areas of the drift-covered regions of Northern Europe, because I think the results obtained are of great interest to glacialists in this country. And for the same reason I wish next to call attention to what has been done of late years in elucidating the Glacial Geology of the Alpine lands of Central Europe—and more particularly of the low grounds that stretch out from the foot of the mountains. Any observations that tend to throw light upon the history of the complex drifts of our own peripheral areas cannot but be of service. It is quite impossible to do justice in this brief sketch to the labours of the many enthusiastic geologists who within recent years have increased our knowledge of the glaciation of the Alpine lands. At present, however, I am not so much concerned with the proofs of general glaciation as with the evidence that goes to show how the Alpine ground-moraines have been formed, and with the facts which have led certain observers to conclude that the Alps have endured several distinct glaciations within Pleistocene times. Swiss geologists are agreed that the ground-moraines which clothe the bottoms of the great Alpine valleys, and extend outwards sometimes for many miles upon the low grounds beyond are of true glacial origin. Now these ground-moraines are closely similar to the Boulder-clays of this country and Northern Europe. Like them, they are frequently tough and hard-pressed, but now and again somewhat looser and less firmly coherent. Frequently also they contain lenticular beds, and more or less thick sheets of aqueous deposits—in some places the stony clays even exhibiting a kind of stratification—and ever and anon such water-assorted materials are commingled with stony clay in the most complex manner. These latter appearances are, however, upon the whole best developed upon the low grounds that sweep out from the base of the Alps. The only question concerning the ground-moraines that has recently given rise to much discussion is the origin of the materials themselves. It is obvious that there

are only three possible modes in which those materials could have been introduced into the ground-moraine: either they consist of superficial morainic débris which has found its way down to the bottom of the old glaciers by crevasses; or they may be made up of the rock-rubbish, shingle, gravel, etc., which doubtless strewed the valleys before these were occupied by ice; or, lastly, they may have been derived in chief measure from the underlying rocks themselves by the action of the ice that overflowed them. The investigations of Penck, Blaas, Böhm, and Brückner appear to me to have demonstrated that the ground-moraines are composed mostly of materials which have been detached from the underlying rocks by the erosive action of the glaciers themselves. Their observations show that the regions studied by them in great detail were almost completely buried under ice, so that the accumulation of superficial moraines was for the most part impossible; and they advance a number of facts which prove positively that the ground-moraines were formed and accumulated under ice. I cannot here recapitulate the evidence, but must content myself by a reference to the papers in which this is fully discussed.[1] These geologists do not deny that some of the material may occasionally have come from above, nor do they doubt that pre-existing masses of rock-rubbish and alluvial accumulations may have been incorporated with the ground-moraines; but the enormous extent of the latter, and the direction of transport and distribution of the erratics which they contain cannot be thus accounted for, while all the facts are readily explained by the action of the ice itself, which used its sub-Glacial débris as tools with which to carry on the work of erosion.

Professor Heim and others have frequently asserted that glaciers have little or no eroding power, since at the lower ends of existing glaciers we find no evidence of such erosion being in operation. But the chief work of a glacier cannot be carried on at its lower end, where motion is reduced to a minimum, and where the ice is perforated by sub-Glacial tunnels and arches, underneath which no glacial erosion can possibly take place; and yet it is upon observations made in just such places that the principal arguments against the erosive action of glaciers have been based. If all that we could ever know of glacial action were confined to what we can learn from peering into the grottoes at the terminal fronts of existing glaciers we should indeed come to the conclusion that glaciers do not erode their rocky beds to any appreciable extent. But as we do not look for the strongest evidence of fluviatile erosion at the mouth of a river, but in its valley- and mountain-tracks, so if we wish to learn what glacier-ice can accomplish, we must study in detail some wide region from which the ice has completely disappeared. When this plan has been followed, it has happened that some of the strongest opponents of glacial erosion have been compelled by the force of the evidence to go over to the other camp. Dr. Blaas, for

[1] Penck: Die Vergletscherung der deutschen Alpen. Blaas: Zeitsch. d. Ferdinandeums, 1885. Böhm: Jahrb. d. k. k. geol. Reichsanstalt, 1885. bd. xxxv. Heft 3. Brückner: Die Vergletscherung d. Salzachgebietes, etc., 1886.

example, has been led by his observations on the glacial formations of the Inn Valley to recant his former views, and to become a formidable advocate of the very theory which he formerly opposed. To his work and the memoirs by Penck, Brückner, and Böhm already cited, and especially to the admirable chapter on glacier-erosion by the last-named author, I would refer those who may be anxious to know the last word on this much-debated question.

The evidence of inter-Glacial conditions within the Alpine lands continues to increase. These are represented by alluvial deposits of silt, sand, gravel, conglomerate, breccia, and lignites. Penck, Böhm, and Brückner find evidence of two inter-Glacial epochs, and maintain that there have been three distinct and separate epochs of glaciation in the Alps. No mere temporary retreat and re-advance of the glaciers, according to them, will account for the phenomena presented by the inter-Glacial deposits and associated morainic accumulations. During inter-Glacial times the glaciers disappeared from the lower valleys of the Alps—the climate was temperate, and probably the snow-fields and glaciers approximated in extent to those of the present day. All the evidence conspires to show that an inter-Glacial epoch was of prolonged duration. Dr. Brückner has observed that the moraines of the last Glacial epoch rest here and there upon löss, and he confirms Penck's observations in South Bavaria that this remarkable formation never overlies the morainic accumulations of the latest Glacial epoch. According to Penck and Brückner, therefore, the löss is of inter-Glacial age. There can be little doubt, however, that löss does not belong to any one particular horizon. Wahnschaffe[1] and others have shown that throughout wide areas in North Germany it is the equivalent in age of the 'Upper Diluvium,' while Schumacher[2] points out that in the Rhine valley it occurs on two separate and distinct horizons. Prof. Andreæ has likewise shown[3] that there is an upper and lower löss in Alsace, each characterized by its own special fauna.

There is still considerable difference of opinion as to the mode of formation of this remarkable accumulation. By many it is considered to be an aqueous deposit; others, following Richthofen, are of opinion that it is a wind-blown accumulation; while some incline to the belief that it is partly one and partly the other. Nor do the upholders of these various hypotheses agree amongst themselves as to the precise manner in which water or wind has worked to produce the observed results. Thus, amongst the supporters of the aqueous origin of the löss, we find this attributed to the action of heavy rains washing over and rearranging the material of the Boulder-clays.[4] Many, again, have held it probable that löss is simply the finest loam distributed over the low grounds by the flood-waters that escaped

[1] Abhandl. z. geol. Specialkarte v. Preussen, etc., bd. vii. heft 1; Zeitschr. d. deutsch. geol. Gesellsch., 1885, p. 204; 1886, p. 367.

[2] Hygienische Topographie von Strassburg i. E., 1885.

[3] Abhandl. z. geol. Specialkarte v. Elsass-Lothringen, bd. vii., heft 2.

[4] Laspeyres: Erläuterungen z. geol. Specialkarte v. Preussen, etc., Blatt Gröbzig, Zörbig, und Petersberg.

from the northern inland ice and the *mers de glace* of the Alpine lands of Central Europe. Another suggestion is that much of the material of the löss may have been derived from the denudation of the Boulder-clays by flood-water, during the closing stages of the last cold period. It is pointed out that in some regions at least the löss is underlaid by a layer of erratics, which are believed to be the residue of the denuded Boulder-clay. We are reminded by Klockmann[1] and Wahnschaffe[2] that the inland ice must have acted as a great dam, and that wide areas in Germany, etc., would be flooded, partly by water derived from the melting inland ice, and partly by waters flowing north from the hilly tracts of Middle Germany. In the great basins thus formed there would be a commingling of fine silt-material derived from north and south, which would necessarily come to form a deposit having much the same character throughout.

From what I have myself seen of the löss in various parts of Germany, and from all that I have gathered from reading and in conversation with those who have worked over löss-covered regions, I incline to the opinion that löss is for the most part of aqueous origin. In many cases this can be demonstrated, as by the occurrence of bedding and the intercalation of layers of stones, sand, gravel, etc., in the deposit; again, by the not infrequent appearance of fresh-water shells; but, perhaps, chiefly by the remarkable uniformity of character which the löss itself displays. It seems to me reasonable also to believe that the flood-waters of Glacial times must needs have been highly charged with finely-divided sediment, and that such sediment would be spread over wide regions in the low grounds—in the slack-waters of the great rivers and in the innumerable temporary lakes which occupied, or partly occupied, many of the valleys and depressions of the land. There are different kinds of löss or löss-like deposits, however, and all need not have been formed in the same way. Probably some may have been derived, as Wahnschaffe has suggested, from the denudation of Boulder-clay. Possibly, also, some löss may owe its origin to the action of rain upon the stony clays, producing what we in this country would call "rain-wash." There are other accumulations, however, which no aqueous theory will satisfactorily explain. Under this category comes much of the so-called *Berglöss*, with its abundant land-shells, and its generally unstratified character. It seems likely that such löss is simply the result of subaerial action, and owes its origin to rain, frost, and wind acting upon the superficial formations, and rearranging their finer-grained constituents. And it is quite possible that the upper portion of much of the löss of the lower grounds may have been reworked in the same way. But I confess I cannot yet find in the facts adduced by German geologists any evidence of a dry-as-dust epoch having obtained in Europe during any stage of the Pleistocene period. The geographical position of our continent seems to me to forbid the possibility of such climatic conditions,

[1] Klockmann: Jahrb. d. k. preuss. geol. Landesanstalt für 1883, p. 262.
[2] Wahnschaffe: *op. cit.* and Zeitschr. d. deutsch. geol. Ges. 1886, p. 367.

while all the positive evidence we have points rather to humidity than dryness as the prevalent feature of Pleistocene climates. It is obvious, however, that after the flood-waters had disappeared from the low grounds of the Continent, subaerial action would come into play over the wide regions covered by Glacial and fluvio-Glacial deposits. Thus, in the course of time, these deposits would become modified,—just as similar accumulations in these islands have been top-dressed, as it were, and to some extent even rearranged. I am strengthened in these views by the conclusions arrived at by M. Falsan, the eminent French glacialist. Covering the plateaux of the Doubs, and widely spread throughout the valleys of the Rhone, the Ain, the Isère, etc., in France, there is a deposit of löss, he says, which has been derived from the washing of the ancient moraines. At the foot of the Alps, where black schists are largely developed, the löss is dark grey; but west of the secondary chain the same deposit is yellowish, and composed almost entirely of siliceous materials, with only a very little carbonate of lime. This *limon* or löss, however, is very generally modified towards the top by the chemical action of rain, the yellow löss acquiring a red colour. Sometimes it is crowded with calcareous concretions; at other times it has been deprived of its calcareous element and converted into a kind of pulverulent silica or quartz. This, the true löss, is distinguished from another *lehm*, which Falsan recognizes as the product of atmospheric action—formed, in fact, in place from the disintegration and decomposition of the subjacent rocks. Even this lehm has been modified by running water—dispersed or accumulated locally, as the case may be.[1]

All that we know of the löss and its fossils compels us to include this accumulation as a product of the Pleistocene period. It is not of post-Glacial age—even much of what one may call the "remodified löss" being of Late Glacial or Pleistocene age. I cannot attempt to give here a summary of what has been learned within recent years as to the fauna of the löss. The researches of Nehring and Liebe have familiarized us with the fact that at some particular stage in the Pleistocene period a fauna like that of the alpine steppe-lands of Western Asia was indigenous to Middle Europe, and the recent investigations of Woldřich have increased our knowledge of this fauna. At what horizon, then, does this steppe-fauna make its appearance? At Thiede Dr. Nehring discovered in so-called löss three successive horizons, each characterized by a special fauna. The lowest of these faunas was decidedly Arctic in type; above that came a steppe-fauna, which last was succeeded by a fauna comprising such forms as Mammoth, woolly Rhinoceros, *Bos*, *Cervus*, Horse, Hyæna, and Lion. Now, if we compare this last fauna with the forms which have been obtained from true post-Glacial deposits—those deposits, namely, which overlie the younger Boulder-clays and flood-accumulations of the latest Glacial epoch, we find little in common. The Lion, the Mammoth, and the Rhinoceros are conspicuous by their absence from the post-Glacial beds of Europe.

[1] Falsan: La Période glaciaire, p. 81.

In place of them we meet with a more or less Arctic fauna, and a high-Alpine and Arctic flora, which, as we all know, eventually gave place to the flora and fauna with which Neolithic man was contemporaneous. As this is the case throughout North-Western and Central Europe, we seem justified in assigning the Thiede beds to the Pleistocene period, and to that inter-Glacial stage which preceded and gradually merged into the last Glacial epoch. That the steppe-fauna indicates relatively drier conditions of climate than obtained when perennial snow and ice covered wide areas of the low ground goes without saying; but I am unable to agree with those who maintain that it implies a dry-as-dust climate, like that of some of the steppe-regions of our own day. The remarkable commingling of Arctic and steppe-faunas discovered by Woldřich in the Böhmerwald [1] shows, I think, that the Jerboas, Marmots, and Hamster-rats were not incapable of living in the same regions contemporaneously with Lemmings, Arctic Hares, Siberian Social Voles, etc. But when a cold epoch was passing away the steppe-forms probably gradually replaced their Arctic congeners, as these migrated northwards during the continuous amelioration of the climate.

If the student of the Pleistocene faunas has certain advantages in the fact that he has to deal with forms many of which are still living, he labours at the same time under disadvantages which are unknown to his colleagues who are engaged in the study of the life of far older periods. The Pleistocene period was distinguished above all things by its great oscillations of climate—the successive changes being repeated, and producing correlative migrations of floras and faunas. We know that Arctic and temperate faunas and floras flourished during inter-Glacial times, and a like succession of life-forms followed the final disappearance of Glacial conditions. A study of the organic remains met with in any particular deposit will not necessarily, therefore, enable us to assign these to their proper horizon. The geographical position of the deposit, and its relation to Pleistocene accumulations elsewhere, must clearly be taken into account. Already, however, much has been done in this direction, and it is probable that ere long we shall be able to arrive at a fair knowledge of the various modifications which the Pleistocene floras and faunas experienced during that protracted period of climatic changes of which I have been speaking. We shall even possibly learn how often the Arctic, steppe-, prairie-, and forest-faunas, as they have been defined by Woldřich, replaced each other. Even now some approximation to this better knowledge has been made. Dr. Pohlig,[2] for example, has compared the remains of the Pleistocene faunas obtained at many different places in Europe, and has presented us with a classification which, although confessedly incomplete, yet

[1] Woldřich: Sitzungsb. d. kais. Akad. d. W. math. nat. Cl., 1880, p. 7; 1881, p. 177; 1883, p. 978.

[2] Pohlig: Sitzungsb. d. Niederrheinischen Gesellschaft zu Bonn, 1884; Zeitschr. d. deutsch. geolog. Ges., 1887, p. 798. For a very full account of the diluvial European and Northern Asiatic mammalian faunas by Woldřich, see Mém. de l'Acad. des Sciences de St. Pétersbourg, viie. sér. t. xxxv. 1887.

serves to show the direction in which we must look for further advances in this department of inquiry.

During the last twenty years the evidence of inter-Glacial conditions both in Europe and America has so increased that geologists generally no longer doubt that the Pleistocene period was characterized by great changes of climate. The occurrence at many different localities on the Continent of beds of lignite and fresh-water alluvia, containing remains of Pleistocene mammalia, intercalated between separate and distinct Boulder-clays, has left us no alternative. The inter-Glacial beds of the Alpine lands of Central Europe are paralleled by similar deposits in Britain, Scandinavia, Germany, and France. But opinions differ as to the number of Glacial and inter-Glacial epochs —many holding that we have evidence of only two cold stages and one general inter-Glacial stage. This, as I have said, is the view entertained by most geologists who are at work on the Glacial accumulations of Scandinavia and North Germany. On the other hand, Dr. Penck and others, from a study of the drifts of the German Alpine lands, believe that they have met with evidence of three distinct epochs of glaciation, and two epochs of inter-Glacial conditions. In France, while some observers are of opinion that there have been only two epochs of general glaciation, others, as, for example, M. Tardy, find what they consider to be evidence of several such epochs. Others again, as M. Falsan, do not believe in the existence of any inter-Glacial stages, although they readily admit that there were great advances and retreats of the ice during the Glacial period. M. Falsan, in short, believes in oscillations, but is of opinion that these were not so extensive as others have maintained. It is, therefore, simply a question of degree, and whether we speak of oscillations or of epochs, we must needs admit the fact that throughout all the glaciated tracts of Europe, fossiliferous deposits occur intercalated among glacial accumulations. The successive advance and retreat of the ice, therefore, was not a local phenomenon, but characterized all the glaciated areas. And the evidence shows that the oscillations referred to were on a gigantic scale.

The relation borne to the glacial accumulations by the old river alluvia which contains relics of Palæolithic man early attracted attention. From the fact that these alluvia in some places overlie glacial deposits, the general opinion (still held by some) was that Palæolithic man must needs be of post-Glacial age. But since we have learned that all Boulder-clay does not belong to one and the same geological horizon—that, in short, there have been at least two, and probably more, epochs of glaciation—it is obvious that the mere occurrence of glacial deposits under Palæolithic gravels does not prove these latter to be post-Glacial. All that we are entitled in such a case to say is simply that the implement-bearing beds are younger than the glacial accumulations upon which they rest. Their horizon must be determined by first ascertaining the relative position in the Glacial series of the underlying deposits. Now, it is a remarkable fact that the Boulder-clays which underlie such old alluvia belong, without exception, to the earlier stages of the Glacial

period. This has been proved again and again, not only for this country but for Europe generally. I am sorry to reflect that some twenty years have now elapsed since I was led to suspect that the Palæolithic gravels and cave-deposits were not of post-Glacial, but of Glacial and inter-Glacial age. In 1871-72 I published a series of papers in the GEOLOGICAL MAGAZINE in which I set forth the views I had come to form upon this interesting question. In these papers it was maintained that the alluvia and cave deposits could not be of post-Glacial age, but must be assigned to pre-Glacial and inter-Glacial times, and in chief measure to the latter. Evidence was led to show that the latest great development of glacier-ice in Europe took place after the southern Pachyderms and Palæolithic man had vacated England—that during this last stage of the Glacial period man lived contemporaneously with a northern and Alpine fauna in such regions as Southern France—and lastly, that Palæolithic man and the Southern Mammalia never revisited North-Western Europe after extreme glacial conditions had disappeared. These conclusions were arrived at after a somewhat detailed examination of all the evidence then available—the remarkable distribution of the Palæolithic and ossiferous alluvia having, as I have said, particularly impressed me. I coloured a map to show at once the areas covered by the glacial and fluvio-Glacial deposits of the last Glacial epoch, and the regions in which the implement-bearing and ossiferous alluvia had been met with, when it became apparent that the latter never occurred at the surface within the regions occupied by the former. If ossiferous alluvia did here and there appear within the recently glaciated areas it was always either in caves, or as infra- or inter-Glacial deposits. Since the date of these researches our knowledge of the geographical distribution of Pleistocene deposits has greatly increased, and implements and other relics of Palæolithic man have been recorded from many new localities throughout Europe. But none of this fresh evidence contradicts the conclusions I had previously arrived at; on the contrary, it has greatly strengthened my general argument.

Professor Penck was, I think, the first on the Continent to adopt the views referred to. He was among the earliest to recognize the evidence of inter-Glacial conditions in the drift-covered regions of Northern Germany, and it was the reflections which those remarkable inter-Glacial beds were so well calculated to suggest that led him into the same path as myself. Dr. Penck has published a map [1] showing the areas covered by the earlier and later glacial deposits in Northern Europe and the Alpine lands, and indicating at the same time the various localities where Palæolithic finds have occurred. And in not a single case do any of the latter appear within the areas covered by the accumulations of the last Glacial epoch.

A glance at the papers which have been published in Germany within the last few years will show how greatly students of the Pleistocene ossiferous beds have been influenced by what is now known of the inter-Glacial deposits and their organic remains.

[1] Archiv für Anthropologie, bd. xv. heft 3, 1884.

Professors Rothpletz[1] and Andreæ,[2] Dr. Pohlig[3] and others, do not now hesitate to correlate with those beds the old ossiferous and implement-bearing alluvia which lie altogether outside of glaciated regions.

The relation of the Pleistocene alluvia of France to the glacial deposits of that and other countries has been especially canvassed. Rothpletz, in the paper cited below, includes these alluvia amongst the inter-Glacial deposits; and in the present year we have an interesting essay on the same subject by the accomplished secretary of the Anthropological and Archæological Congress, which met last month in Paris. M. Boule correlates[4] the Palæolithic cave- and river-deposits of France with those of other countries, and shows that they must be of inter-Glacial age. His classification, I am gratified to find, does not materially differ from that given by myself a number of years ago. He is satisfied that in France there is evidence of three Glacial epochs and two well-marked inter-Glacial horizons. The oldest of the Palæolithic stages of Mortillet (Chelléenne) culminated according to Boule during the last inter-Glacial epoch, while the more recent Palæolithic stages (Moustérienne, Solutréenne, and Magdalénienne) coincided with the last great development of glacier-ice. The Palæolithic age, so far as Europe is concerned, came to a close during this last cold phase of the Glacial period.

There are many other points relating to Glacial Geology which have of late years been canvassed by continental workers, but these I cannot discuss here. I have purposely, indeed, restricted my remarks to such parts of a wide subject as I thought might have interest for glacialists in this country, some of whom may not have had their attention directed to the results which have recently been attained by their fellow-labourers in other lands. Had time permitted I should gladly have dwelt upon the noteworthy advances made by our American brethren in the same department of inquiry. Especially should I have wished to direct attention to the remarkable evidence adduced in favour of the periodicity of glacial action. Thus Messrs. Chamberlin and Salisbury, after a general review of that evidence, maintain that the Ice Age was interrupted by one chief inter-Glacial epoch, and by three inter-Glacial sub-epochs or episodes of deglaciation. The same authors discuss at some length the origin of the löss, and come to the general conclusion that while deposits of this character may have been formed at different stages of the Glacial period, and under different conditions, yet that upon the whole they are best explained by aqueous action. Indeed a perusal of the recent geological literature of America shows a close accord between the theoretical opinions of many transatlantic and European geologists.

Thus as years advance the picture of Pleistocene times becomes

[1] Rothpletz: Denkschrift d. schweizer. Ges. für d. gesammt. Nat., bd. xxviii. 1881.

[2] Andreæ: Abhandl. z. geolog. Specialkarte v. Elsass-Lothringen, bd. iv. heft 2, 1884.

[3] Pohlig: *op. cit.*

[4] Boule: Revue d'Anthropologie, 1889, t. i.

more and more clearly developed. The conditions under which our old Palæolithic predecessors lived—the climatic and geographical changes of which they were the witnesses—are gradually being revealed with a precision that only a few years ago might well have seemed impossible. This of itself is extremely interesting, but I feel sure that I speak the conviction of many workers in this field of labour when I say that the clearing up of the history of Pleistocene times is not the only end which they have in view. One can hardly doubt that when the conditions of that period and the causes which gave rise to these have been more fully and definitely ascertained, we shall have advanced some way towards the better understanding of the climatic conditions of still earlier periods. For it cannot be denied that our knowledge of Palæozoic, Mesozoic, and even early Cainozoic climates is unsatisfactory. But we may look forward to the time when much of this uncertainty will disappear. Meteorologists are every day acquiring a clearer conception of the distribution of atmospheric pressure and temperature, and the causes by which that distribution is determined, and the day is coming when we shall be better able than we are now to apply this extended meteorological knowledge to the explanation of the climates of former periods in the world's history. One of the chief factors in the present distribution of atmospheric temperature and pressure is doubtless the relative position of the great land and water areas; and if this be true of the present, it must be true also of the past. It would almost seem then as if all one had to do to ascertain the climatic condition of any particular period was to prepare a map, depicting with some approach to accuracy the former relative position of land and sea. With such a map could our meteorologists infer what the climatic conditions must have been? Yes, provided we could assure them that in other respects the physical conditions did not differ from the present. Now there is no period in the past history of our globe the geographical conditions of which are better known than the Pleistocene. And yet, when we have indicated these upon a map, we find that they do not give the results which we might have expected. The climatic conditions which they seem to imply are not such as we know did actually obtain. It is obvious, therefore, that some additional and perhaps exceptional factor was at work to produce the recognized results. What was this disturbing element, and have we any evidence of its interference with the operation of the normal agents of climatic change in earlier periods of the world's history? We all know that various answers have been given to such questions. Whether amongst these the correct solution of the enigma is to be found time will show. Meanwhile, as all hypothesis and theory must starve without facts to feed on, it behoves us as working geologists to do our best to add to the supply. The success with which other problems have been attacked by geologists forbids us to doubt that ere long we shall have done much to dispel some of the mystery which still envelopes the question of geological climates.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
SEPTEMBER 12TH to 18TH, 1889.

List of Titles of Papers read in Section (C) Geology.

Professor JAMES GEIKIE, D.C.L., LL.D., F.R.S., F.G.S., President.

The President's Address. (See page 461.)

Prof. J. Milne.—Report on the Earthquake and Volcanic Phenomena of Japan.

Prof. G. Michie Smith.—The Bandaisan Eruption, Japan, July, 1888.

Dr. E. Naumann.—Terrestrial Magnetism as modified by the Structure of the Earth's Crust; and Proposals concerning a Magnetic Survey of the Globe.

T. P. Barkas.—Notes on numerous newly discovered Fossil Footprints on the Lower Carboniferous Sandstone of Northumberland, near Otterburn.

T. Mellard Reade.—The Physiography of the Lower Trias.

Dr. A. Geikie.—Origin and Age of the Crystalline Schists of Norway.

J. E. Marr.—Dynamic Metamorphism of Skiddaw Slates.

Dr. F. H. Hatch.—On the Lower Silurian Felsites of the South-East of Ireland.

A. R. Hunt.—The Age of the Granites of Dartmoor and the English Channel.

R. Swan.—The Island of Paros, in the Cyclades, and its Marble Quarries.

Prof. T. G. Bonney.—Preliminary Note on the alleged Occurrence of Fossils in the Crystalline Schists of the Lepontine Alps.

W. W. Watts.—To exhibit Specimens of Belemnites from Lukmanier.

Prof. T. G. Bonney.—Effects of Pressure on Crystalline Limestone.

J. J. H. Teall.—The Amygdaloids of the Tynemouth Dyke.

Dr. F. Nansen.—Greenland.

Prof. C. Williamson.—Report on Coal Plants; on the Present State of Inquiry into the Microscopic Features of the Coals of the World, and into the Organization of the Fossil Plants of the Coal-Measures.

Prof. T. Rupert Jones.—Report upon the Fossil Phyllopoda of the Palæozoic Rocks.

Dr. H. J. Johnston-Lavis.—Report on the Volcanic Phenomena of Vesuvius.

Prof. E. Hull.—To exhibit Specimens of supposed Coral Structures from Culdaff in Donegal, and to invite opinions thereon.

Prof. E. Hull.—To exhibit a small block of magnetically polar diorite.

A. C. G. Cameron.—Note on the recent exposures of Kellaway's Rock at Bedford.

G. R. Vine.—Polyzoa of the Red Chalk.

W. A. E. Ussher.—The Devonian Rocks of Great Britain.

John Marley and Professor G. A. Lebour.—Sketch of the Rise and Progress of the Cleveland and South Durham Salt Industry, and on the Extension of the Durham Coal-field.

C. E. De Rance.—Report of the Committee on the Circulation of Underground Waters.

Dr. D Embleton.—On the Spinal Column of *Loxomma Allmanni* from the Northumberland Coal-field.

Dr. R. Laing.—The Bone Caves of Cresswell, with the recent discovery of an Extinct Feline (*Felis brevirostris*) new to Great Britain.

Dr. R. H. Traquair—On the Devonian Fishes of Canada.

A. Smith Woodward.—On the Occurrence of the Devonian Ganoid *Onychodus* in Spitzbergen.

A. Smith Woodward.—Notes on some new and little-known British Jurassic Fishes. (See page 448.)

Prof. A. W. Rücker and *Prof. T. E. Thorpe.*—On the Relation between the Geological Constitution and the Magnetic State of the United Kingdom.

Prof. A. C. Haddon.—Notes on the Geology of Torres Straits.

G. W. Lamplugh.—Report on an Ancient Sea Beach near Bridlington.

Dr. H. W. Crosskey.—Report on Erratic Blocks.

W. Whitaker.—On a Deep Channel filled with Drift in the Valley of the Cam, Essex.

H. H. Howorth.—Are the extreme Glacial Views developed by Agassiz and his scholars consistent with our Present Geological Knowledge?

G. W. Lamplugh.—Note on a New Locality for the Arctic Shell-beds of the Basement Boulder-clay on the Yorkshire Coast.

H. H. Howorth.—Did the great Rivers of Siberia flow Southwards and not Northwards in the Mammoth Age?

E. B. Dorsey.—On the Witwatersrand Gold Fields.

A. Bell.—Report on the Manure Gravels of Wexford.

Prof. F. Clowes.—On Waterbox Deposits and their Bearing on the Cementing Material of Rocks.

J. Starkie Gardner.—Report on the Eocene Plants of the Isle of Wight.

Prof. A. H. Green.—A word or two about the so-called Concretions in the Magnesian Limestone of Durham.

W. Topley.—The Work of the Geological Survey in Northumberland and Durham.

R. Tiddeman.—On Concurrent Faulting and Deposit (Craven, Yorkshire), with a note on Carboniferous Reefs.

List of Papers bearing on Geology read before other Sections.

Section A. (Mathematical and Physical Science.)

Report of the Committee on Underground Temperature.

Section B. (Chemical Science.)

J. Pattinson and Dr. H. S. Pattinson.—On Chilian Manganese Ore.

Prof. Frank Clowes.—On Barium Sulphate Deposits from the Waters of Durham Coal-mines and in Nottingham Sandstone.

Report of the Committee on the Formation of a Uniform System of Recording the Results of Water Analysis.

Section D. (Biology.)

Prof. H. F. Osborn.—The Palæontological Evidence for the transmission of acquired characters.

R. Irvine and G. Sims Woodhead.—On the Secretion of Carbonate of Lime by Animals.

W. S. Anderson.—The Solubility of Carbonate of Lime in Fresh and Sea Water.

Dr. Traquair.—Restoration of *Asterolepis maximus* (Agassiz), with remarks on the Zoological affinities of the Pterichthyidæ.

Section E. (Geography.)

Joseph Thomson.—Report to the Committee appointed to investigate the Geography and Geology of the Atlas Ranges in the Empire of Morocco.

W. J. Flinders Petrie.—Wind Action in Egypt.

Section F. (Economic Science and Statistics.)

Prof. Edward Hull.—The State of our Coal Resources.

Prof. Edward Hull.—Diagram showing the rate of Production of Coal during the present Century.

Section G. (Mechanical Science.)

C. E. De Rance.—Records of River Volumes and Flood Levels.

CORRESPONDENCE.

Sir,—So many of your readers must go Alp-wards that I appeal, though late, to any who may visit the Chamounix district, to help me in a little investigation by looking out for diorites about the junction of the gneiss with the protogine—the inner portions of de Saussure's "Artichoke." I am prevented from doing so myself this year.

Last summer I picked up a worn pebble in the gorge below Pierre a l'Echelle, and above Pierre Pointue, both mere cockney points of interest on the way up Mont Blanc.

I do not remember any mass of diorite thereabouts. But it appears at intervals from the Mottets[1] to the upper Grands Mulets. I did not climb in search, not having sufficient time left.

My specimen proved to be an epidiorite, under the microscope, with slightly banded structure. Hornblende, not orientated, probably of augitic origin, showed two periods, one, the older, giving the usual pleochroic green and yellow, the other nearly colourless, with a cement, so to speak, of the secondary hornblende. The cleavage continued through this portion. There is apatite, plagioclase and a ground mass which I have not properly investigated.

I feel sure that careful study would give interesting results if this contact-region were investigated. Something like what my section gives is shown in Teall's grand book, at plate 17.

The problem of at least two periods of formation of the hornblende points to an interesting history of the Mont Blanc "Artichoke" formation period.

Marshall Hall.

Grosvenor Club, *September*, 1889.

[1] The rocks exposed close to the Glacier des Bois and Mer de Glace.